C-18

Assessment of Small Scale Biomass Cogeneration in the State of Michigan

Prepared for the

Michigan Biomass Energy Program
Public Service Commission
Michigan Department of Commerce
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July 1994

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INTRODUCTION

Energy is the lifeblood of the economic process. In Michigan, as elsewhere, most of the state's energy needs are being met by oil, coal, natural gas and nuclear power plants. Although wood supplied much of the state's energy needs in the past, few contributions from renewable energy technologies have recently occurred.

In recent years several large scale biomass energy facilities have come on line, yet even these account for only one percent of the state's electricity supply. Michigan Public Service Commission policies have favored these large scale energy facilities, making it very difficult for smaller facilities to overcome cost barriers. However, with rising energy costs, shrinking landfill space, technological innovations and increasing concern for environmental degradation, biomass fuels are once again offering a unique opportunity to help meet the state's growing energy needs and provide cost savings to a large number of Michigan industries.

With significant amounts of biomass residues currently being disposed of as waste, this resource is ripe for use in Michigan and consistent with the *Michigan Solid Waste Management Act* and the *Michigan Wood Energy Development Plan*. Combined, these two planning documents provide clear priorities for wood wastes—reduce, reuse, and recycle, recover lost energy, and then landfill as a last resort.[1] According to a 1991 listing compiled by the Michigan Department of Labor, Boiler Division, more than 400 wood or waste fired boilers are currently being utilized in Michigan to provide space or water heating, process needs, electricity generation or some combination of the above.[2]

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1. The *Solid Waste Management Act* (i.e., Public Act 641 of 1978) provides a hierarchy for managing the states municipal solid waste. The ***Michigan Wood Energy Development Plan, An Addendum to Michigan's Forest Resources, A Statewide Forest Resources Plan*** was completed in 1986 and intended to facilitate development of a portion of Michigan's wood resources for energy production with consideration for multiple-use and environmental concerns.

2. The Michigan Department of Labor, Bureau of Constructions Codes, Boiler Division is responsible for inspecting boilers throughout the state of Michigan and compiles the data in a Boilers database from which this information was derived.

The most recent study by the Great Lakes Regional Biomass Energy Program notes that just over 90 facilities were utilizing wood combustion systems in 1988. See the Great Lakes Regional Biomass Energy Program, *Biomass Energy Facilities 1988 Directory of the Great Lakes Region*, Council of Great Lakes Governors, Chicago, Ill. This obvious discrepancy in the number of wood fired boilers in Michigan may reflect a small number of boiler users responding to the Great Lakes Region survey at the time.

Consistent with the relatively large number of existing wood fueled combustion facilities operating in Michigan, a recent assessment of renewable energy resources in the Midwest noted, "[B]iomass energy could supply a very large fraction of the midwest's electricity needs at a moderate cost."[3]

Although this recent Midwest study estimates a significant electricity potential from utilizing biomass in large utility scale plants, the potential from small scale cogeneration in many of the state's existing industries provides a relatively untapped opportunity. The *Michigan Electricity Options Study* (MEOS),[4] although recognizing the cogeneration potential in the forest products industries, also estimated the state's biomass electricity potential based on facilities more similar to conventional power plants, rather than cogeneration facilities.

Cogeneration is the sequential production of electrical or mechanical energy and thermal energy from the same fuel source. Consistent with this technological capability to generate electricity in conjunction with process needs, overall fuel use is more efficient than otherwise attainable in conventional generating facilities. Interestingly, relatively little emphasis has been placed on utilizing available biomass residues to estimate the cogeneration potential from the state's existing wood fueled facilities, or other facilities which currently utilize boilers and could retrofit or convert to biomass.

Although there has been a heightened interest in utilizing biomass waste resources to supply energy, help meet Federal clean air standards and ease the burden on the shrinking number of landfills, large facilities—like the recent wood-fired power plant in Cadillac, Michigan—still dominate much of the energy developer's interest as long as there are adequate fuel supplies.

Unfortunately, relatively little data has been compiled in Michigan to assist these smaller potential cogenerators to evaluate resource availability and economic viability. In fact, these same wood fuel users are up against this "large scale only" thinking right from the start as they attempt to gather information on the feasibility of smaller cogeneration projects.

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3. See Michael C.Brower, Michael W. Tennis, Eric W. Denzler, and Mark M. Kaplan, *Powering the Midwest: Renewable Electricity for the Economy and the Environment*, a report by the Union of Concerned Scientists, Cambridge, MA, 1993, page 63.

4. The *Michigan Electricity Options Study* was initiated in 1985 and completed in 1987 under the direction of the Michigan Department of Commerce. The study was designed to generate information and analyses to assist utility planners, state regulators and other interested parties in making economically sound judgements regarding the potential contribution of utility and non-utility supply and displacement options for meeting Michigan's uncertain electricity needs over the next 20 years.

To utilize Michigan's biomass resource in a sustainable manner and reap all the potential statewide benefits, it is first necessary to determine where the wastes are, what they are and how much is available for energy conversion. Without this preliminary information, energy planning and a move towards utilization of renewable resources will be constrained.

The purpose of this report is to gather some of this information and provide useful policy oriented analysis regarding biomass cogeneration capabilities in some of the state's relatively small scale industrial facilities. Using available information on biomass resources, conversion technologies, cost data and industry statistics to accomplish this goal, this report provides much useful information, analysis and insight for further analysis and potential new policy directions.

The study includes: (a) an updated assessment of the biomass residue available for energy conversion; (b) an estimate of the technical cogeneration potential given the biomass residue constraint; (c) an evaluation of the economic cogeneration potential given this same biomass residue constraint; (d) an estimate of the market penetration of cogeneration; and (e) an identification of the barriers to greater penetration of biomass cogeneration.

And finally, the last section of the report provides insights gleaned from the analysis performed and survey data reviewed. Policy recommendations and areas for further study to improve future assessments are included to help expand the market penetration of small scale biomass cogeneration and investments in Michigan's economic future.

BIOMASS WASTE INVENTORY

There are nine major sources of existing biomass waste currently or potentially available for use as energy feedstocks in Michigan. These include:

* Harvest residues from logging
* Residues produced at primary wood-using mills
* Residues from secondary wood products manufacturers
* Agricultural residues
* Animal manures
* Solid waste from municipal landfills
* Urban wood wastes
* Residues from the food processing industry
* Residues from wastewater treatment facilities

Some of the wastes noted here may not be conducive to burning as fuel in many of the conventional industry biomass boilers—due to non-uniform sizes, emissions from chemicals, paints and or other contaminants (e.g., mixed wastes from landfills, wood composites, residues from wastewater treatment facilities). Nevertheless, many can be burned in other waste-to-energy type facilities, or captured as gases in new bioconversion technologies (e.g., ethanol from mixed waste paper or methane from landfills or animal manures), and are included in this analysis of available volumes and energy heat value.[5]

Similarly, estimates for agricultural residues are included to provide a more comprehensive evaluation of the broad resources available in Michigan. Identifying the full range of biomass resources can also provide a basis for understanding the potential employment and economic related benefits that might arise from a stronger emphasis on biomass energy production and the emerging technologies available to convert these products into biofuels or for direct combustion.

In an effort to provide the reader, energy planners and policy makers with the most useful, comprehensive and up-to-date information available, a variety of sources were used to gather the necessary data. These included: published residue data from state and

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5. For more discussion of some of these alternative or emerging technologies see, among others Noni L. Strawn, "The Biofuels Vision," *Biologue*, Volume II Number 1, Spring 1993, National Wood Energy Association, Washington, DC, page 4-8; "Anaerobic Digestion Process Produces Methane," *Biomass Digest*, Volume I Number 2, Summer 1992, Western Regional Biomass Energy Program, Golden, CO; *Electricity From Biomass: A Development Strategy*, U.S. Department of Energy, Solar Thermal and Biomass Power Division, Office of Solar Energy Conversion, April 1992; and James D. Kerstetter and John Kim Lyons, *Mixed Waste Paper to Ethanol Fuel: A Technology, Market, and Economics Assessment for Washington*, Washington State Energy Office, 1991.

Federal agencies, independent assessments, and data from recent surveys. All this was supplemented with information gathered from interviews with agency personnel and estimates where necessary.

Once compiled, the data was recorded by county and ultimately by region. The following figures identify the eight regions and the respective counties in each region, both in text and on a map.

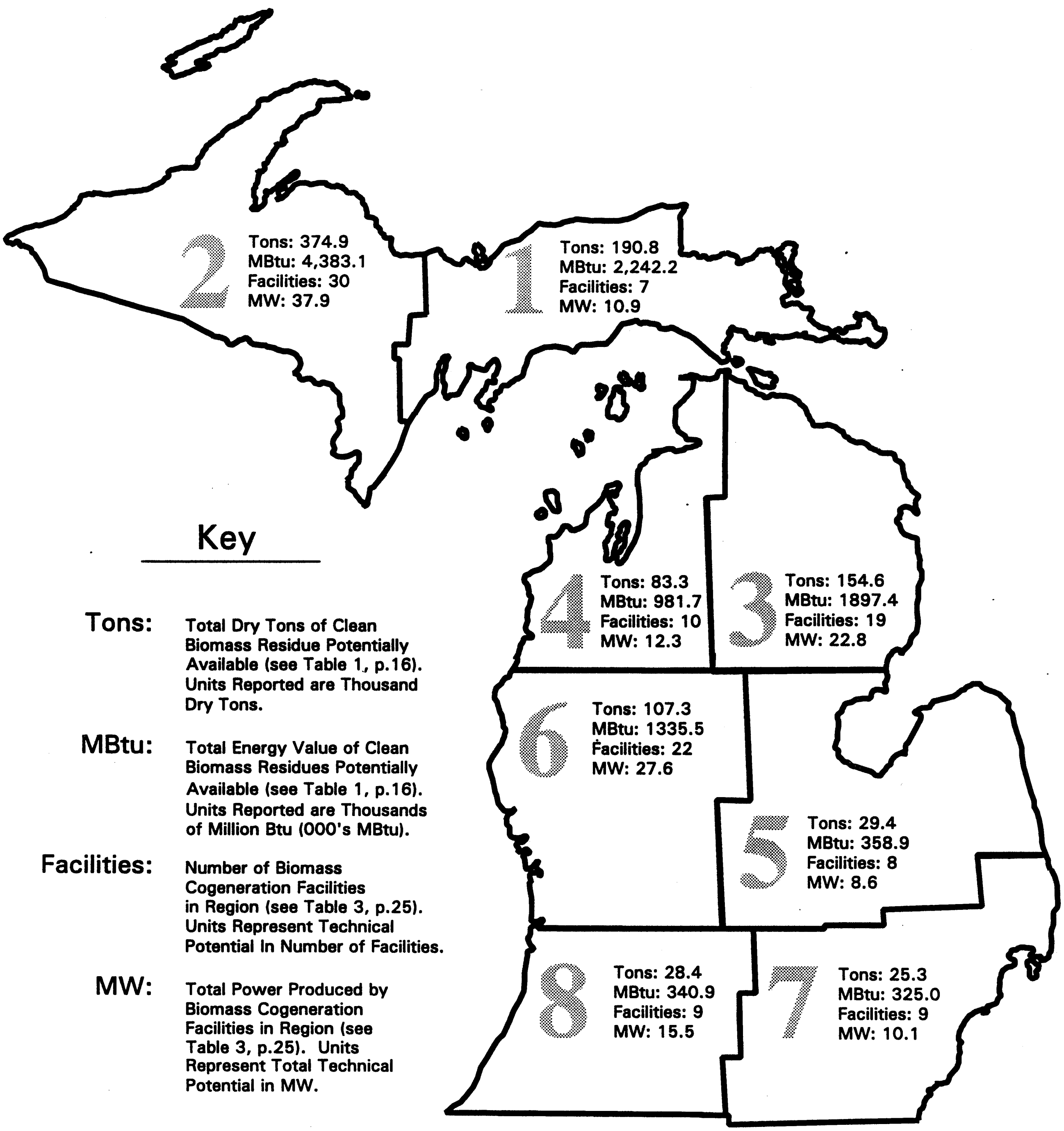
While there is a substantial amount of information available on some of the biomass residues, such as forest harvesting residues, others, such as residues from the food processing industry and sewage treatment wastes, are sorely lacking. In instances where the available data bases were fragmented and clearly underestimated the total resource, such as may be the case in the total residues reported from the secondary wood products industry, we have made projections for the total resource based on volume and respondent ratios as reported. Needless to say, there are many potential discrepancies and a strong need for additional, more extensive surveys and research.

Unfortunately, similar to other states, there is no consistent or centralized reporting of waste streams in the state of Michigan. Nevertheless, there are numerous opportunities and incentives to collect these unused wastes for use as raw materials in manufacturing, as fuel in industry processes, and to generate electricity for in-house needs and/or potential sales to local utilities.

Figure 1. Regional Distribution By County

Upper Peninsula	Northern-Lower Peninsula	Mid-Lower Peninsula	Southern-Lower Peninsula
Eastern - Region 1	**Eastern - Region 3**	**Eastern - Region 5**	**Eastern - Region 7**
Alger	Alcona	Arenac	Hillsdale
Chippewa	Alpena	Bay	Ingham
Delta	Cheboygan	Clinton	Jackson
Luce	Crawford	Genesee	Lenawee
Mackinac	Iosco	Gladwin	Livingston
Schoolcraft	Montmorency	Gratiot	Macomb
West - Region 2	Ogemaw	Huron	Monroe
Baraga	Oscoda	Lapeer	Oakland
Dickinson	Otsego	Midland	St. Clair
Gogebic	Presque isle	Saginaw	Washtenaw
Houghton	Roscommon	Sanilac	Wayne
Iron	**Western - Region 4**	Shiawassee	**Western - Region 8**
Keweenaw	Antrim	Tuscola	Allegan
Marquette	Benzie	**Western - Region 6**	Barry
Menominee	Charlevoix	Clare	Berrien
Ontonagon	Emmet	Ionia	Branch
	Grand traverse	Isabella	Calhoun
	Kalkaska	Kent	Cass
	Leelanau	Lake	Eaton
	Manistee	Mason	Kalamazoo
	Missaukee	Mecosta	St. Joseph
	Wexford	Montcalm	Van buren
		Muskegon	
		Newaygo	
		Oceana	
		Osceola	
		Ottawa	

FIGURE 2. MAP OF REGIONAL DISTRIBUTION



METHODOLOGY

When available, data is reported in many different forms. In some instances residues are reported by volume, such as cubic feet, while others are reported in individual units or by weight. In some cases it was necessary to extrapolate the resource from population estimates (e.g. solid waste) or utilize coefficients to determine such things as the percentage of residues left in the forest. In other cases it was necessary only to convert reported volumes into a weight basis (dry tons) and then into millions of Btu (MBtu) heat value. The methodology used to derive the respective residues and to make the conversions for each type is described below. A complete listing of the volume to weight and heat value conversion factors used for each of the residues is contained in the Appendix.

Harvest Residues from Logging

Harvest residues from logging were derived from the most recent U.S. Forest Service timber assessments for the Michigan region.[6] These residues consist of all wood fiber (e.g., tops, limbs, cull materials and some growing stock material) left behind from trees cut during logging operations on timberlands and not subsequently used for industrial products. These harvest residues are often referred to as slash and are traditionally left in the forest.

The Forest Service reports that 431 million cubic feet (mcf) of industrial roundwood[7] was harvested in 1992 and approximately 19 percent (82.7 mcf) remained as harvest residues. This represents an increase in total harvest volumes and residues of just over 2 percent compared with 1990 harvest data. In addition to these harvest residues directly associated with product extraction there were an estimated 45.2 mcf of other residues not directly associated with product extraction left in the forest.[8]

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6. Preliminary data tables for 1992 were obtained from Dennis May, Research Forester, U.S.D.A. North Central Forest Inventory and Analysis Unit, St. Paul, Minn., in June 1994. This data is being used to update the most recent 1990 timber assessments; see Ronald L. Hackett and John Pilon, *Michigan Timber Industry—An Assessment of Timber Product Output and Use, 1990*, United States Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN, Resource Bulletin NC-144, April 1993.

7. Roundwood refers to logs, bolts, or other round sections cut from trees (including chips from roundwood). Industrial roundwood products include: saw logs, pulpwood, veneer logs, poles, commercial posts, particleboard bolts, chips from roundwood used for pulp or board products, etc.).

8. The category of "other removals" includes residues that result from cultural operations (e.g., timber stand improvement practices), pre-commercial thinnings, land-use changes (clearing) and others. The 1992 volume of other removals is based on data provided by Dennis May at the North Central Forest Experiment

Consistent with sustainable forestry practices some of this residue must be left on the forest floor to ensure adequate return of nutrients and biodiversity. In the absence of any clear guidelines for determining what percentage of residues should be left we rely, as did the Union of Concerned Scientist's (UCS) assessment, on a ratio of 50 percent and assume the remainder can be collected and utilized.[9] The available residues were converted from thousands of cubic feet to dry tons utilizing a ratio of 14.7 dry tons per 1,000 cubic feet of residue.[10]

Residues Produced at Primary Wood-Using Mills

Residues produced at primary wood-using mills were also derived from the most recent U.S. Forest Service assessments for the Michigan region.[11] Residues from these mills includes coarse, fine and bark residues from softwoods and hardwoods. Residues are typically used to produce fiber products, chipped and/or used as is for industrial fuel, domestic fuel, livestock bedding mulch, small dimension lumber or specialty items.

Total residue produced from these Michigan mills was estimated at 1,310.17 thousand tons green weight. Of this total, only 47.07 thousand tons (3.6 percent) was reported as "not used". Once again, these green weights were converted into dry tons using a conversion ratio for mill residues supplied by the Forest Service.[12] Based on the information available it is not clear whether these unused residues are being piled "out-back" at the respective mills or are being disposed of in landfills. Regardless of the disposition, we assumed 100 percent of these unused residues were available.

Station. According to Mr. May the most recent assessment of "other removals" was done in 1991. At that time they were estimated to be approximately 51.185 mcf (10.5 percent of the projected total industrial roundwood harvests estimated at 488 mcf). Although the total volume harvested— used as a basis for the 1991 other removals estimate—was higher than actually occurred, we were able to derive a 1992 estimate by using this same ratio applied to available harvest and residue data.

9. See Michael C. Brower, et. al., *Powering The Midwest*, op. cit., pages 35-36.

10. This ratio is based on data provided by Anthony Weatherspoon, Utilization & Marketing Specialist, Forest Management Division, Michigan Department of Natural Resources, in a personal communication in June 1994.

11. See Dennis May, op. cit.

12. The conversion ratios for wood residues were derived from a table titled "Factors to estimate wood residues generated per standard unit of mill production by product, species group, and type of residue," supplied by Dennis May. Based on Forest Service assessments we also note that 661.1 thousand dry tons were used for industrial fuel and 79.4 thousand dry tons were used for residential fuel in 1992.

Residues from Secondary Wood Products Manufacturers

Residues from secondary wood products manufacturers were based on a database of survey responses from a recent survey of 1,687 manufacturers by the Michigan Department of Natural Resources, Forest Management Division (DNR/FMD).[13]

The residues from these manufacturers were divided into two classes. These include (1) clean wood residues such as chips, shavings, sawdust, scraps, cut offs, etc.; and (2) other wood and paper residues such as all of the above that were combined with wood composites, plastics, laminates, particle board, paperboard, office paper, cardboard, coated papers, pallets, dunnage,[14] etc..

The distinction between the two types was made to allow further analysis of those residues that can readily be burned in industry boilers versus those that are possibly more suitable for waste-to-energy facility type burners at this time. More specifically, we chose to separate out any residues that may pose potential fuel problems due to uniformity of size constraints and/or emissions from chemicals, paints or other contaminants.

To further refine our analysis of the residues available from the secondary wood products manufacturers we omitted any volumes of bark reported by these manufacturers as landfilled. This was done to ensure that no "double counting" of these materials was done since bark is usually associated with the primary wood products industries and would be reported in the primary mill residue data.[15] As a final step we developed coefficients based on the survey respondent distribution by geographic area, fuel type reported and percentage of total survey population to derive residue estimates for the entire industry.

Agricultural Residues

Due to the varied and relatively detailed issues surrounding the collection of agricultural residues (e.g., estimating lands currently in conservation reserve programs, erosion constraints and harvesting practices) the agricultural residues considered in this study are

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13. For a detailed discussion of the survey and analysis of the results see Carolyn J. Randall, *Michigan Wood and Paper Residue Study, Secondary Wood Products Manufacturers*, Forest Management Division, Michigan Department of Natural Resources, Lansing, Michigan, March 1994. However, we relied on our analysis of the volumes and weights of landfilled residues contained in the computer database provided us by Ms. Randall. Our totaling of the residues reflected higher amounts than those reported in the study.

14. This refers to the various materials (usually wooden boards) used on trucks or when stacking wood to provide space (i.e., between the stacking surface and the wood) for easier lifting and ventilation.

15. This same point is noted in the written report, Ibid., page 19.

taken directly from the assessments for Michigan made in the UCS study.[16] The authors of that study examined all crops currently planted and harvested in Michigan including corn, soybeans, wheat, dry beans, oats, barley among others. The estimates consider only those lands available for harvesting, and multiplied yields per acre by residue factors. These values were then adjusted for a minimum one ton per acre left in the field and then a maximum farmer participation rate of 50 percent.

Unfortunately, a region by region assessment of the available residues was unavailable. Although we have included their assessment of the total resource collectable (at prices ranging from $50 to $90 per ton delivered) as a statewide total, it appears the most significant residues are concentrated in the lower peninsula in the mid and lower regions (primarily our regions 6, 7 and 8).[17]

Animal Manures

There is currently no published data available on volumes of animal manure generated in the state of Michigan. However, agricultural statistics which include livestock and poultry are available.[18] In order to provide the necessary manure weight estimates for millions of cows, pigs, sheep and chickens living on Michigan's farms, we utilized coefficients—for each of the respective animal types—derived from a survey of agricultural waste products in the state of Maine.[19] Horses, another large source of animal manure, were not included in these estimates since no population data was available.

With the appropriate coefficients (i.e., manure per animal) established we assumed that only 25 percent of these wastes were collectable and available due to the varied nature of animal confinement practices and the existing beneficial practice of spreading manures

16. See Michael J. Brower, et. al., *Powering The Midwest*, op. cit., pages 39-40 et seq.

17. For more detail on the crops covered and assumptions made see the UCS study cited above page 39. Although not covering the state of Michigan, a detailed analysis of estimating crop residues is available in K. Shaine Tyson, *Resource Assessment of Waste Feedstocks for Energy Use in the Western Regional Biomass Energy Area*, Energy and Environmental Analysis Division, Solar Energy Research Institute [now the National Renewable Energy Laboratory], Golden, CO, February 1991.

18. See Michigan Agricultural Statistics Service, *Michigan Agricultural Statistics 1993*, U.S. Department of Agriculture, Lansing, MI, August 1993.

19. See Bill Seekins and Laura Mattei, *Update: Usable Waste Products for the Farm*, Maine Department of Agriculture, Food, and Rural Resources, Augusta, ME, 1990.

on agricultural lands for fertilizer.[20] And for consistency in reporting we converted the green manure weights to dry weights assuming a 50 percent moisture content for green.

Solid Waste from Municipal Landfills

To estimate the amount of solid waste available for combustion or bioconversion, we once again relied on coefficients due to a lack of published data on this potential resource.[21] To calculate the recoverable resource we utilized resident population figures from the latest census data for Michigan,[22] average landfill disposal rates per person and materials characterizations.[23]

In calculating this potential resource we assumed all wastes landfilled are available for recovery. To help ensure a minimum of "double-counting" we also subtracted those residues reported as landfilled by the secondary wood products industry from the totals obtained here.[24]

Other Residues

Three additional biomass residue sources were identified as potential feedstocks for energy generation. Unfortunately, for each of the respective sources, including urban wood wastes, residues from the food processing industry and residues from wastewater treatment facilities, we were unable to find any published or compiled data for Michigan.

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20. Spreading manure on agricultural lands has resulted in excessive nutrient and salt concentrations and ground water contamination in some areas and could significantly decrease the amounts being spread. In this instance the 25 percent noted as available should be viewed as a conservative estimate.

21. According to a personal communication with Sharon Edgar, Unit Chief, Solid Waste Alternative Program, Michigan Department of Natural Resources, Waste Management Division, in June 1994, no estimates or studies have been done since the 1980s. Ms. Edgar did note however, that they have no reason to believe Michigan generation rates per person differ from the national average of 4.3 pounds per person per day.

22. See *Summary Population and Housing Characteristics 1990*, U.S. Department of Commerce, Bureau of the Census, Washington, DC.

23. Based on information provided by Sharon Edgar (cited above) on per person waste generation rates in Michigan we similarly adopted national landfill disposal estimates of 2.9 pounds per person per day and waste composition estimates by type and percentage as noted in Franklin Associates Ltd., *Characterization of Municipal Solid Waste in the United States: 1992 Update*, prepared for the U.S. Environmental Protection Agency, 1992.

24. Due to the lack of information on current waste-to-energy powerplants there is a strong possibility that a portion of the combustible solid waste resource noted here is currently being utilized.

Of these potentially significant sources of biomass in Michigan— which all warrant further study—only one, urban wood waste is soon to be assessed.[25]

Contrary to the biomass resource estimates provided in the UCS study, the focus of this study is limited to available biomass residues and we have chosen to not include energy crops. However, these plantations of short rotation woody crops and herbaceous energy crops have been touted by researchers and energy experts as "likely to become the predominant biomass resource over the coming two decades," and could provide a significant biomass resource in Michigan.[26]

RESIDUE ASSESSMENT

The state of Michigan as a whole has a combined total of almost 5.7 million dry tons of biomass residues currently available for biomass cogeneration or other uses.[27] As the following tables indicate, we estimate that less than 20 percent (just under 1 million dry tons) of this total meets our criteria for "clean biomass residues" and is used in further analysis of small scale biomass cogeneration potential. We've made this distinction to provide what we consider the most accurate assessment of those residues which could easily (given current technologies and cultural practices) be collected, processed and transported for use as energy fuels in industrial boilers. This includes residues from

25. Public Policy Associates of Lansing, Michigan was awarded a contract by the Great Lakes Regional Biomass Energy Program, Chicago, IL, to assess the processing and utilization of urban wood waste and pallets for fuel in the region. The study is expected to be completed in the fall of 1994.

26. For more information on this resource and its potential energy and economic benefits see, among others, Jane Hughes Turnbull, *Principles and Considerations for Biomass Resource Development*, a paper submitted for presentation at the 1993 Biomass Conference of the Americas. Ms. Turnbull does research and analysis for the Electric Power Research Institute, Palo Alto, CA. For an assessment of the potential in Michigan see Michael C. Brower, et. al., *Powering The Midwest*, op. cit., pages 42-48.

27. This estimate is based on our analysis of the respective residue sources noted above. See Tables 1 and 2 for more details on the specific residues. Another recent assessment notes there are 34.7 million tons available, however this includes energy crops and ours did not and may also reflect different coefficients for calculating residue volumes. For more details see Tom Stanton, "Biomass Energy: It's Not Just for Breakfast Anymore," a paper written as part of the *Michigan Biomass Energy Initiative Briefing Book*, and the *Michigan Biomass Energy Program, Biofuels User Manual* (in press). Mr. Stanton is Coordinator for the Michigan Biomass Energy Program, Michigan Public Service Commission.

Based on a recent listing of wood energy facilities, with annual biomass usage above 25,000 green tons, there are 20 large scale facilities in Michigan utilizing a total of 2.66 million green tons annually (sources and type of fuel are not listed). See Robin Bertsch and Anthony Weatherspoon, *Wood Products in Michigan Mills and Manufacturers (Primary and Value-Added Manufacturers)*, Forest Management Division, Michigan Department of Natural Resources, Lansing, MI., August 1991, page vi.

harvesting, and those found in the wood products and food processing industries (our target industries for analysis).

By making this distinction we knowingly set aside more than 60 percent of the wood, paper and other potentially combustible wastes currently being landfilled by the secondary wood products industry and all of the other potentially available residues (i.e., agricultural residues, manures, solid waste residues, sewage treatment waste, etc.). The extent to which these mixed wastes might pose problems due to chemical or other contaminants or sizing problems is enough to deter many biomass fuel users. However, given more aggressive sorting or utilization in facilities more amenable to these wastes, they represent another significant potential biomass resource for small scale cogeneration or other biomass fueled facilities.

TABLE 1. CLEAN BIOMASS RESIDUES POTENTIALLY AVAILABLE IN MICHIGAN
(THOUSAND DRY TONS AND THOUSAND MBTU)

Type of Residue	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Total
Harvest (000 Dry Tons)	188.0	371.7	143.9	81.7	25.4	92.6	11.5	25.1	939.9
Energy Value (000 MBtu)	2,180.5	4,311.9	1,668.8	948.1	295.0	1,074.6	132.9	290.7	10,902.6
Primary Mill (000 Dry Tons)	2.8	3.2	9.9	1.5	1.3	6.7	0.0	0.5	25.9
Energy Value (000 MBtu)	61.6	71.2	218.4	33.6	27.7	146.7	0.1	10.9	570.4
Secondary Manufacturers									
Clean wood only (000 Dry Tons)	0.0	0.0	0.8	0.0	2.6	8.0	13.8	2.8	28.1
Energy Value (000 MBtu)	0.1	0.0	10.1	0.0	36.2	112.2	191.9	39.3	389.7
Total Dry Tons (000)	190.8	374.9	154.6	83.3	29.4	107.3	25.3	28.4	993.8
Total Energy Value (000 MBtu)	2,242.2	4,383.1	1,897.4	981.7	358.9	1,333.5	325.0	340.9	11,862.6

Viewed on a weight or energy value (MBtu) basis the western half of the upper peninsula (region 2) represents approximately 37 percent of the state's total available "clean wood resource." However, when we consider all of the state's potential biomass resources noted in the following tables, we see that the southeastern portion of the lower peninsula has more than 2.5 times as much available biomass than the next largest regional resource. This comes as no surprise, since more than 97 percent of the resource is from solid waste, and the population in the region equals almost 40 percent of the statewide total.[28]

The northeastern portion of the lower peninsula (region 3) leads all other regions with just under 10 million dry tons of biomass residues available from the region's primary wood mills. This too comes as no surprise given the abundant pine and aspen forests in that region. Region 6, the middle western portion of the lower peninsula, also prolific with pine and aspen, is close behind, accounting for almost 7 million dry tons of mill residues. These two regions are followed by those in the upper peninsula which together account for another 7 million dry tons.

In contrast to these recent biomass residue estimates, the MEOS study identified approximately 8.1 million green tons of unused harvest residues and .39 million green tons of unused mill residues.[29] The available harvest residues (1986 estimates) are more than 4 times greater than the residue volumes we report (converting to green tons). Consequently, the available energy value from the resource is proportionally larger. This large difference may be due in part to the percentage of residue left in the forest or differences in coefficients used to convert the residues to tons.

Contrary to this large difference in harvest residues, the MEOS reporting of mill residues is much more consistent with ours when converted to green tons. Aside from these harvest and mill residues, and solid waste for waste-to-energy development, the MEOS study does not appear to account for any other potential biomass residues which might be available (e.g., agricultural residues, paper and wood wastes) for electricity generation. However, some of these residues, especially those from the secondary wood products industry, if landfilled, will be captured in the solid waste estimates (we adjusted the solid waste totals to avoid "double counting" in our analysis).

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28. This estimate is based on 1990 census data. See *Summary Population and Housing Characteristics 1990*, op. cit., for more detail.

29. See ICF Corporation, *The Potential for Biomass, Waste to Energy, and Hydroelectric Power in Michigan*, Final Report presented to The Michigan Electricity Options Study, January 1987, Table 2-1 on pages 2-5 and Table 2-3 on page 2-15.

Table 2. Other Biomass Residues Potentially Available in Michigan (Thousand Dry Tons and Thousand MBtu)

Type of Residue	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Total
Secondary Manufacturers									
Other wood and paper (000 Tons)	0.0	0.0	1.6	0.2	1.8	4.4	24.8	10.2	43.0
Energy Value (000 MBtu)	0.0	0.1	19.3	2.9	24.1	54.0	323.8	137.3	561.6
Municipal Solid Waste (000 Tons)	18.8	36.9	31.6	40.8	215.5	198.8	877.1	159.9	1,579.5
Energy Value (000 MBtu)	316.4	619.8	542.0	686.1	3,633.9	3,381.5	14,868.1	2,729.4	26,777.2
Manures (000 Tons)	43.9	25.3	91.5	101.5	553.6	576.9	411.0	644.9	2,448.7
Energy Value (000 MBtu)									n/a
Food Processing (000 Tons)									n/a
Energy Value (000 MBtu)									n/a
Sewage Treatment (000 Tons)									n/a
Energy Value (000 MBtu)									n/a
Crop residues (Tons)									3,061.0
Energy Value (000 MBtu)									52,700.0
Pallets (000 Tons)									n/a
Energy Value (000 MBtu)									n/a
Total dry ton (000)	18.8	36.9	33.2	41.0	217.2	203.2	901.9	170.2	4,683.5
Total Energy Value (000 MBtu)	316.4	619.9	561.3	689.0	3,658.0	3,435.5	15,191.9	2,866.7	80,038.8
TOTAL ALL dry tons (000)	209.6	411.8	187.8	124.3	246.6	310.5	927.2	198.5	5,677.3
TOTAL ALL Energy Value (000 MBtu)	2,558.6	5,003.1	2,458.7	1,670.7	4,016.9	4,768.9	15,516.9	3,207.6	91,901.4

Notes: "TOTAL ALL" refers to Total "Clean Biomass" residues from the previous table and Total "Other Biomass" residues from this table.

A more recent assessment of biomass residues by the UCS identified 558,000 tons of logging residues, significantly lower than our estimates. This too may be due to differences in coefficients since we used the same coefficient as UCS for estimating residues to be left in the forest. Primary mill residues (after accounting for the differences between wet and dry) are similar to our estimates. The UCS study also identifies a variety of other potential biomass resources, similar to our assessment.

OTHER DEMAND FOR BIOMASS RESIDUES

While there appears to be a fairly large resource of "unused" biomass residues currently available, increasing pressure to decrease harvesting in the state's forests is impacting the supply and demand for these residues. Utilization of these residues, whether they be from the forest, mills or the landfill, is not limited exclusively to industrial energy users and residents burning wood products for space heating. Wood recycling is on the rise, and similar to other raw materials, the continuing supply of these residues for energy fuels will be determined by weighing their energy value (i.e., how much users are willing to pay) against the value of using them to create other economically valuable products.

Although there is little available data on the extent of these other uses (e.g., numbers of users, volumes being used, disposition by type, cost, value added, etc.) there appears to be an increasing demand, new products are emerging[30] and conferences are being held.[31] This demand includes but is not limited to the following:

- Animal bedding (paper, cardboard, sawdust, ground wood, chips and shavings) primarily for poultry litter and horse bedding).

- Landscaping (sawdust, chips and shavings, shredded pallets) for ground covers, mulch, erosion control and as feedstock for making compost.

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30. The recent DNR/FMD survey asked respondents questions regarding disposition of wastes and included landscape, animal bedding and "other" as options. For more details and the results see Carolyn J. Randall, *Michigan Wood and Paper Residue Study*, op. cit. For additional information on new products from wood waste see a number of articles in *Wood Recycler*, a new monthly publication by Robert White, on wood recycling and other wood recovery related issues, N.Plymouth, MN, and contact Rita Roche, Midwest Research Institute, Kansas City, MO, for a series of technical papers produced in cooperation with the U.S. Forest Service in 1992, on forest based micro-enterprise ideas.

31. The Southeast Regional Biomass Energy Program in Muscle Shoals, AL, is sponsoring a conference and exposition "Wood Recycling: Opportunities for Waste Generators and Solid Waste facilities in the Southeast," in July, 1994.

- Fiberboard and particleboard (fiber made from construction debris, demolition materials, sawdust, shavings, urban wood waste, etc.) to make furniture, kitchen cabinets, office work stations, etc..

- Cement mixtures (ground wood and waste products mixed with portland cement) to produce molded products such as pallet stringers, wheel chocks and bicycling and walking paths.

- Wood curls (wood trimmings) to produce wood curls used in potpourri mixes, animal bedding, fireplace and campfire kindling, floral arrangements, craft items, and as an alternative to styrofoam peanut packing material.

- Hydraulic mulch (fiber made from construction debris, demolition materials, sawdust, shavings, urban wood waste, etc.) - mixed with grass seed and fertilizer mixture and spread with hydro seeders at highway projects, golf courses and other sites.

TECHNICAL POTENTIAL FOR BIOMASS COGENERATION

Technical potential for small scale biomass cogeneration refers to the total electricity capacity (in megawatts) that can be generated from cogeneration facilities without any economic constraints. However, for our purposes we limited the scope of the analysis and imposed four constraints in estimating this potential: (1) facilities must currently utilize boilers (either fossil fuel or biomass fueled) to provide process steam needs; (2) facilities are within the wood products industry or food processing industry; (3) the necessary biomass fuels are only those "clean wood biomass residues" identified in Table 1 as potentially available for biomass cogeneration; and (4) only facilities in each of the respective regions may utilize fuels from the region (i.e., residues generated in a region would not be utilized outside of the region).

With this criteria established we then modeled fuel usage and electricity generation for the target facilities based on boiler size and cogeneration equipment specifications. Due to the relatively limited amount of biomass available, we gave biomass fuel preference to those facilities in each region which have existing biomass fired boilers providing process steam. These facilities would only require the addition (retrofit) of cogeneration equipment to generate electricity. The remainder of the biomass fuels available were then distributed by respective region to those facilities that are currently using fossil fuel boilers (coal and natural gas) and would require more extensive conversions for biomass cogeneration.

This preference reflects the significantly smaller amounts of biomass fuels required by the existing biomass boiler facilities (i.e., only the additional fuel necessary for cogeneration needs) compared with the larger amounts for the other facilities (i.e., for those facilities requiring a conversion to biomass fuels we assumed all their boiler and cogen fuel needs would need to be met with biomass). This analysis makes no provision for co-firing of biomass fuels with other fuels such as coal nor does it assume any use of biogasses.[32]

Contrary to this approach, the MEOS study utilized available residue estimates (adjusting for other existing uses—similar to our approach) converted tonnages to the amount of available energy (MBtu) and divided by a heat rate of 16,500 Btu per kilowatt-hour to derive the technical electricity generating potential. Similarly, to determine the technical capacity they simply divided the generating potential by 8,760 (hours in a year) and then

32. For a recent economic and technical assessment of co-firing coal and biomass, including a cogeneration facility in Flier City, Michigan, see The Irland Group, *Assessment of Situation and Potential For Co-Firing Coal And Biomass In Energy Facilities*, prepared for the Great Lakes Regional Biomass Energy Program, Council of Great Lakes Governors, Inc., Chicago, Illinois, March 1993.

adjusted for a 65 percent utilization or capacity rate (i.e., a standard industry capacity). Their result was 775 megawatts. This analysis, while reasonable for estimating the potential for large scale wood-fired powerplants, is inconsistent with our attempts to assess the cogeneration potential at many of the state's smaller manufacturing facilities and therefore does not provide a meaningful basis for comparison.

Upon beginning our investigation we found there to be little information available to identify this select group, their steam needs, electricity usage patterns, boiler types, types of fuel burned or other necessary information. Although the MEOS appears to have utilized an extensive database of Michigan industries, that database was not available to us, nor do we know what level of detail or accuracy was reported. Ideally, a comprehensive survey of this industry population should have been done, but a survey of that magnitude was beyond the scope and financial constraints inherent in this study.

Nevertheless, with access to the DNR/FMD database of survey respondents, a database from the Michigan Department of Labor,[33] manufacturer's census data[34], and communication with industry representatives and biomass experts we were able to develop an industry population and data for identifying a typical boiler and cogeneration equipment with which to proceed.[35]

METHODOLOGY

Utilizing the facility populations and employment data derived from the various data sources, we then estimated the total population, boiler sizes and distribution of facilities in the wood products and food processing industries that currently utilize boilers to

33. This refers to a 1991 Michigan Department of Labor Boiler Inspections Database, Bureau of Constructions Codes/Boiler Division provided by Tom Stanton, Biomass Program Coordinator, Michigan Public Service Commission. This database includes approximately 400 listings of facilities which use wood or waste fired boilers. Follow-up calls to the Boiler Division resulted in no additional information on other boilers used in the state or breakout by industry sector or fuels used.

34. See *1991 Annual Survey of Manufacturers, Statistics for Industry Groups and Industries*, U.S. Department of Commerce, Bureau of the Census, December 1992; and *1991 Annual Survey of Manufacturers, Geographic Area Statistics*, U.S. Department of Commerce, Bureau of the Census, February 1993.

35. Emerging technologies referred to as "micro or mini" turbines have been identified as another possible alternative to capture steam for "cogeneration" that is currently being vented into the air. Further analysis of this option revealed an extremely limited base of information from manufacturers and the need for a significant amount of site specific information upon which to proceed. Given these constraints we recognize that this technology may soon provide an additional means of generating electricity in many industries throughout Michigan, but we have not included it in this assessment of biomass cogeneration potential.

generate steam needs. This involved a similar process as that used to develop projections made for residue volumes in the secondary products industry—we developed coefficients (based on the number of survey respondents and total survey population) and deducted projected numbers of existing biomass cogeneration facilities to ensure as little "double counting" as possible.

We then developed two separate scenarios to represent the diverse number of different boiler sizes and types, and cogeneration equipment that could be used in the target industries with existing biomass boilers and those without. With the lack of detailed information and no provision for an extensive industry-wide survey, this approach, although based on reasonable assumptions and similar to other studies of this nature, carries with it a significant chance of error—and is not meant to be a definitive assessment of technical potential in the facilities noted. Nevertheless, given the information that was available, this approach provides a reasonable assessment of capacity, generation capabilities and biomass fuel usage, and serves as a useful benchmark for further study and policy analysis.

Based on boiler size data from the DNR/FMD survey[36] the two sizes modeled are intended to capture the full range of those facilities with boilers smaller and larger. The modeling includes: (1) a 20,700 pound per hour boiler with a single stage noncondensing steam turbine/generator (500 kW capacity); and (2) a 60,000 pound per hour boiler with a single stage noncondensing steam turbine/generator (1,665 kW capacity). Each of the systems has an inlet steam pressure of 250 pounds per square inch gauge (psig) and exhaust pressure of 15 psig. Boiler efficiency is 65 percent, turbine/generator efficiency is 50 percent, and each system has a turbine steam rate (TSR) of 20.72 pounds per kilowatt-hour.[37]

The capacity factor for each of the systems is 65 percent and reflects an electrical generating potential of 2.84 megawatt hours per year for the smaller systems and 9.48 megawatt-hours for the larger system.

Given these parameters we then inputed the available residue volumes (MBtu energy values) and the number of large and small existing biomass fired boilers for each of the

36. Survey responses to boiler size were coded as smaller than 50,000 pounds per hour and greater than 50,000 pounds per hour.

37. For more detail on sizing specifications see Gerald R. Guinn, *Design Manual for Small Steam Turbines*, U.S. Department of Energy Regional Biomass Program, National Fertilizer Development Center, Resource Development Group, Muscle Shoals, AL, March 1990; and James L. Easterly and Michael Z. Lowenstein, *Cogeneration From Biofuels: A Technical Guidebook*, Tennessee Valley Authority Biomass Program, Southeastern Regional Biomass Energy Program, Muscle Shoals, AL, October 1986. Additional data for sizing, fuel usage and electrical generating capacities were obtained from Dr. Gerald Guinn, Johnson Research Center, University of Alabama-Huntsville, AL.

fossil fuels) to determine the number of facilities (given the industry facility population constraints). The two step process reflects a preference for those facilities already using biomass and thus require significantly less additional biomass to cogenerate. Facilities not currently using biomass fuels were assumed to use biomass fuel to meet all of their process steam needs.

TECHNICAL ASSESSMENT

The technical potential for biomass cogeneration is 145.8 megawatts (given the residue and facility constraints noted above) from a total of 99 facilities currently using biomass boilers to generate steam needs and 15 facilities not currently using biomass boilers. The combined electricity generating potential is approximately 825,818 megawatt-hours.[38]

As the following table indicates, given the available residues, facilities with existing biomass boilers represent almost 84 percent of the technical biomass cogeneration potential. Region 2, the western portion of the upper peninsula, could supply nearly 40 megawatts, almost 26 percent of the state's potential. This is not surprising given the significantly larger volume of available residues and the higher number of facilities currently using biomass fuels in their boilers.

Although region 1 in the eastern portion of the upper peninsula has the second largest volume of available residues it ranks sixth highest in potential capacity (accounting for a total of just under 11 megawatts). This is due to the small number of existing biomass fueled facilities. Nevertheless, combined, the upper peninsulas account for just over one-third of the total technical potential capacity in megawatts.

Following region 1, region 6 in the lower midwestern portion of the state, accounts for 27.6 megawatts, the second largest technical potential. This reflects a relatively large volume of available fuel (the third highest) but more importantly, the second largest number of potential industry facilities. Region 3 in the northeastern portion of the lower peninsula is close behind accounting for just under 23 megawatts.

38. Had we not constrained the fuel supply to the 993.8 thousand dry tons "clean wood residues" and the limited number of facilities, the technical capacity would have been much greater. For instance, another study estimates more than 8,000 MW of capacity would be available from a total biomass resource of 34.7 million tons. Although not noted specifically in the report, we assume this estimate is based on a methodology consistent with estimating capacity for large scale generating plants—similar to that used by MEOS and the UCS study in their technical potential estimates—rather than smaller scale cogeneration facilities as we have, and accounts for no residue or facility constraints. See Tom Stanton, "Biomass Energy: It's Not Just for Breakfast Anymore," op. cit.

Table 3. Biomass Cogeneration Technical Potential Using Clean Wood Residues

Region	Available Fuel (000 MBtu)	Biomass Fueled Boilers			Fossil Fuel Boilers			Technical Potential	
		Facil	MW	MWh	Facil	MW	MWh	Total MW	Total MWh
Region 1	2,242.2	4	5.3	24,650	3	5.6	31,763	10.9	56,413
Region 2	4,383.1	24	28.1	161,174	6	9.8	55,657	37.9	216,831
Region 3	1,897.4	17	19.0	108,082	2	3.8	21,911	22.8	129,993
Region 4	981.7	9	10.3	58,781	1	2.0	11,174	12.3	69,955
Region 5	358.9	7	8.2	46,456	1	0.5	2,663	8.6	49,119
Region 6	1,333.5	21	25.6	146,005	1	2.0	11,410	27.6	157,415
Region 7	325.0	8	9.8	55,937	1	0.3	1,621	10.1	57,558
Region 8	340.9	9	15.5	88,534	0	0.0	0	15.5	88,534
Total	11,862.6	99	121.9	689,619	15	23.9	136,199	145.8	825,818

Notes: Clean wood residues refers to all available residues from harvesting, primary wood industries, and those residues from the secondary wood products industry (with the exception of particlė board, composites, plastic, papers, cardboard, pallets, dunnage or other residues which might impose non-uniform size constraints or contain contaminants).

ECONOMIC POTENTIAL FOR BIOMASS COGENERATION

To evaluate the economic potential for utilizing biomass resources for cogeneration, we began with the numbers of facilities noted to have technical potential and determined the cost-effectiveness of retrofitting them with electrical generating equipment or converting boilers to burn biomass and adding electrical generating equipment. In utilizing this approach, we analyzed the total costs per kilowatt-hour (kWh), including amortized capital costs, operations and maintenance costs and the incremental fuel costs,[39] and savings from electricity generated. We then developed a "simple payback" assessment for each type of installation. In other words, the number of facilities having economic potential is a subset of those facilities having technical potential.

Consistent with the focus of this study and the analysis used to develop the technical potential, we once again concentrate on the industrial facilities in the wood products industries and food processing industries which have process steam needs.

It is interesting to note that this emphasis on meeting facility steam needs (combined with cogeneration of electricity) with biomass is contradictory to the MEOS assessment. In estimating the economic potential for biomass the MEOS study recognized the potential for using biomass in this manner, especially in the wood products industry where residues are available, but chose not to evaluate wood energy for cogeneration. This limited scope was used as a means to address what could have been a "double-counting" problem (i.e., other MEOS work groups were studying the potential for cogeneration within the same pool of steam users). As an alternative to using biomass residues in cogeneration applications, it appears the MEOS study assumed all available biomass would be used in wood-fired powerplants.[40]

The focus of the current study was not to assess the use of biomass in dedicated wood-fired powerplants, but rather biomass cogeneration potential in existing industries. We analyzed the economic potential for biomass cogeneration identifying three types of installations, these include: (1) facilities already using biomass in boilers to generate process or plant needs that could be retrofit with electrical generating equipment for cogeneration; (2) facilities currently using natural gas in boilers to generate process or plant needs and could be converted (i.e., replaced) with boilers capable of burning biomass and electrical generating equipment for cogeneration; and (3) facilities currently

39. The incremental fuel costs refer to those additional costs associated with electrical generation and the additional fuel requirements associated with utilizing biomass rather than existing fossil fuel sources.

40. For more discussion on these points and the assessment of the economic potential by MEOS see ICF Corporation, *The Potential for Biomass, Waste to Energy, and Hydroelectric Power In Michigan*, op.cit., Chapter Two: Biomass, pages 2-1 through 2-22.

using coal in boilers to generate process or plant needs and could be converted (or replaced) with boilers capable of burning biomass and electrical generating equipment for cogeneration.

METHODOLOGY

With little plant specific information upon which to do a more sophisticated economic analysis, we chose a more broad based and simplified approach to costing known as simple payback. This approach, determining the payback period for an investment, is recognized as a useful tool for preliminary cost analysis and is consistent with the level of policy inquiry being undertaken here. The results establish a clear boundary of opportunity.

Utilizing the distribution of facilities by size and type we then developed capital cost and financing estimates, operating and maintenance costs, and boiler fuel costs. To accomplish this we relied on a number of recent studies, our own survey of equipment manufacturers and personal communications with industry representatives and biomass experts.[41]

As the following table indicates we used an average cost of $620 per kW for retrofitting an existing wood-fired boiler facility with electric cogenerating capabilities. This is considerably lower than the $1,835 per kW for converting an existing gas-fired boiler facility with a biomass-fired boiler and electrical cogenerating capabilities, and the $1,100 per kW for converting an existing coal-fired boiler facility with a biomass-fired boiler and electrical cogenerating capabilities.

Utilizing these cost and generation estimates we then calculated the amortized cost, energy saving benefits, the total cost per kWh, and subsequently the "simple payback."[42]

41. Among others see Michael C. Brower, et. al., *Powering The Midwest*, op. cit.; James D. Kerstetter, *Biomass Resources*, Staff Issue Paper 89-41, Northwest Power Planning Council, Portland, OR, October 1989; *1991 Northwest Conservation and Electric Power Plan*, Volume II Part II, Northwest Power Planning Council, Portland, OR; George Wiltsee, *Biomass Fueled Cogeneration Systems*, Southeastern Regional Biomass Energy Program, Tennessee Valley Authority, Muscle Shoals, AL, December 1993; Laila Guessous and John G. Cleland, *Wood Energy Guide For North Carolina*, North Carolina Division of Forest Resources, Department of Environment, Health and Natural Resources, Raleigh, NC, June 1993; and *Co-Generation Feasibility Analysis for the MTE Sawmill*, Draft Report, CERT Technical Services Corporation, Denver, CO, June 10, 1991.

42. This analysis assumes all electricity generated by the facilities is used in-house (i.e., no electricity sales to utilities), biomass residues average $1.79 per MBtu ($25 per ton delivered), coal $1.44 per MBtu, natural gas $2.71 per MBtu, and no utility standby charges are incurred.

To derive the simple payback in years the following formula is used:

$$(AmC \times AmL) / (EsB - (O\&MC + FC) \times ElG)$$

Where:

	AmC	= Amortized Cost
	AmL	= Amortized Life (years)
	EsB	= Energy saving Benefits (kWh generated—no longer purchased— times the utility cost per kWh)
	O&MC	= Operating and Maintenance Cost per kWh
	FC	= Incremental Fuel Cost per kWh
	ElG	= Electricity generated (kWh)

Once we established the simple payback, we calculated the "hurdle rate" or the equivalent of a return on investment. The formula is:

$$1 / \text{simple payback (number of years)}$$

Based on required industry payback information derived from the DNR/FMD survey data and a limited survey of Michigan area lending institutions, we used a maximum simple payback of 7.5 years—a hurdle rate of 13.5 percent—as our baseline for determining economic potential.

Consistent with this approach, MEOS also uses a hurdle rate to assess economic potential. However, the MEOS assessment uses a rate of 20 percent reflecting a 4 to 5 year payback they considered realistic at the time.[43] Hurdle rates vary significantly from business to business and individual to individual. For this reason, and accounting for an increasing level of awareness and timing of investments tied to retooling,[44] we

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43. For more details on the logic behind this see Meta Systems Inc., *Michigan Electricity Options Study, Contract 3A: Commercial and Institutional Cogeneration*, Final Report, January 1987, page 4-10; and Dunn & Bradstreet Technical Economic Services, *Michigan Electricity Options Study, Contract 3C: Industrial Cogeneration Analysis*, 1987, page 23.

44. In this instance, retooling refers to the major overhauling or replacing of boilers and other related production or process equipment, usually occurring on a cycle. According to personal communications with Neal Elliott, an engineer and Research Associate at the American Council for An Energy-Efficient Economy, in May and June of 1994, the lumber and wood products industry and pulp and paper mills rarely replace their boilers due to the significant costs involved, unless environmental regulation or other significant process changes occur. Their boilers usually last from 15 to 30 years, some as long as 50 years depending on the level of maintenance. Dr. Elliott also noted that boilers in the food processing industry, another good candidate for using biomass cogeneration due to their generation of in-house residues, are typically less expensive than those in the other industries noted and are replaced every 15 to 20 years.

relied more heavily on information provided by area lenders and chose to adopt a lower rate.[45]

The following table provides much of the data we used in estimating the simple paybacks and for other economic analysis.

TABLE 4. ESTIMATED BIOMASS COGENERATION COSTS FOR A 500 KW FACILITY

	Wood-Fired Cogen Retrofit	Natural Gas Conversion	Coal Conversion
Cost per kW	$620	$1,835	$1,100
Total capital cost	$310,000	$917,500	$550,000
Interest rate (percent)	10%	10%	10%
Amortization period (years)	15	15	15
O&M cost ($/kWh)	$0.015	$0.015	$0.015
Incremental Fuel cost ($/kWh)	$0.007	$0.008	$0.061
Electricity generated (MWh/year)	2,844	2,844	2,844
Capacity factor	.65	.65	.65

Notes: The costs per kW noted in this table are based on cost estimates from many sources and reflect potentially higher costs for site specific retrofits or conversions than what otherwise may be achievable. Fuel costs reflect the incremental or additional fuel required for the cogen process or the conversion of gas and coal fired boilers to wood, based on current fuel cost estimates. Although amortized over a 15 year period, the actual life may be 20 to 25 years; this may overstate the costs over the life of the facility, but for our purposes of looking at policy considerations, this may not be an important factor.

45. The higher hurdle rate referenced by MEOS reflects what may be a realistic rate for those companies which are in the early stages of their retooling cycle (i.e., recently purchased new equipment or rebuilt). However, for those facilities approaching the middle or end of a retooling cycle—when a facility is planning for and needs to make equipment or system changes anyway—the hurdle rate is significantly diminished.

ECONOMIC ASSESSMENT

The economic potential for biomass cogeneration in Michigan is approximately 122 MW.[46] This analysis reflects the number of facilities that have a combined capital, O&M and incremental fuel cost lower than the existing per kWh rate paid,[47] as well as a simple payback of 7.5 years or less. With this as the base criteria, all 99 of the existing wood-fired facilities identified as having technical potential noted earlier, have economic potential to be retrofitted with cogenerating equipment to produce electricity. Those facilities having the technical potential, given the availability of biomass residues, to convert to biomass (i.e., existing natural gas and coal facilities with process steam needs) did not meet the above criteria.

As the table on the following page indicates, approximately two-thirds of the economic potential is derived from the lower peninsula although the upper peninsula eastern region leads the state with just over 28 MW of potential (23 percent of the combined total). This region is closely followed by the lower peninsula midwestern region at 25.6 MW, the northeastern region at 19 MW and the southeastern region at 15.6 MW. The four remaining regions range from a low of 5.3 MW to a high of just over 10 MW.

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46. Although the analysis differs in many respects, it is interesting to note in comparison, the MEOS study in estimating the economic potential of wood-fired powerplants identified 282 MW of electricity that could be generated at $0.07 to $0.09 cents per kWh—mid 1986 dollars—(this refers to the electricity price already paid by a facility or the buyback rate offered). For more details on this analysis see *The Potential for Biomass, Waste to Energy, and Hydroelectric Power in Michigan*, op. cit., page 2-2.

Similarly, in estimating the potential capacity that could be generated in powerplants using wood/wood wastes the UCS study estimated 18 MW at less than $0.07 per kWh based on conventional technology. With advanced technologies the study notes that significantly more capacity could be generated, as much as 526 MW at less than $0.07 per kWh. For more details on this analysis see Michael C. Brower, et. al., *Powering The Midwest*, op. cit., page A-36.

47. We assumed an industrial rate of $0.053 per kWh for the target industry population, although, depending on the utility service area this price may be too low, which would tend to underestimate the energy savings. This rate is based on analysis of utility data reported in *Financial Statistics of Major Investor-Owned Electric Utilities 1991*, and *Financial Statistics of Major Publicly Owned Electric Utilities 1991*, both from the Energy Information Administration, Washington, DC.

TABLE 5. ECONOMIC POTENTIAL FOR BIOMASS COGENERATION

Region	Number of Facilities	Total MW	Total MWh
Region 1	4	5.3	24,650
Region 2	24	28.1	161,174
Region 3	17	19.0	108,082
Region 4	9	10.3	58,781
Region 5	7	8.2	46,456
Region 6	21	25.6	146,005
Region 7	8	9.8	55,937
Region 8	9	15.6	88,534
TOTAL	99	121.9	689,619

Notes: The data and calculations in this table are based on modeling of representative biomass facilities by Economic Research Associates using a hurdle rate of 13.5 percent as a minimum, biomass cost of $25 per dry ton and a utility electricity rate of approximately $0.053 per kWh. Totals may not add up due to rounding.

There are a variety of other factors which can significantly influence the economic potential of biomass cogeneration. We find that a lower cost of biomass fuel—which can occur from unwanted residues, availability of in-house residues, or even the use of residues to offset rising disposal costs—can cause the simple payback for those facilities not currently burning biomass residues to meet the criteria for economic potential.

For instance, assuming the same coefficients used in the base scenario above, but varying the cost of biomass from the current $15 to $30 per ton range identified in Michigan to $10 per ton yields per kWh costs well below $0.053 (i.e., the typical industrial cost per kWh) and a payback of 6.1 years for retrofits, 6.2 years for gas conversions, and just over 7.5 years for coal conversions. Given this scenario, the economic potential would rise another 24 MW.[48]

Additional factors which can influence the cost-effectiveness of these investments and warrant further study include: emerging or advanced technologies with greater efficiencies and/or lower capital costs,[49] utility electricity rates and standby rates, diminishing fossil fuel supplies and rising costs, utility information programs or other incentives, property and/or income tax incentives, tax depreciation schedules, and environmental regulations.[50]

OTHER CONSIDERATIONS

While the cost per kWh and the payback warrant significant consideration from the facility decision-maker's perspective, from an overall statewide policy perspective there are additional benefits to consider well beyond increasing the individual plants competitiveness.

Utilizing previously unused forest and mill residues can not only help ease the increasing burden on the state's landfills and provide an opportunity to offset criteria air emissions (when used to replace fossil fuel burning), but also creates additional employment opportunities, tax revenues and an environment for helping to sustain communities.[51]

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48. This increase in capacity is lower than might have been expected. Capturing the additional potential from converting facilities requires a significantly larger volume of biomass to meet process needs as well, not merely the additional biomass required for cogenerating equipment in the wood-fired retrofits. The potential is therefore constrained by fuel availability.

49. The U.S. Department of Energy is funding research and development activities to accelerate the development of biomass conversion technologies and energy plantations. See the *Biofuels Program Plan FY 1992 - FY1996*, National Renewable Energy Laboratory, Golden, CO, page 11, prepared for the U.S. Department of Energy, January 1993. Consistent with this, the UCS study cited earlier notes on page A-36, that the state of Michigan has the potential to produce 152 Trillion Btu from energy crops and a capacity ranging from 8 MW using conventional technologies to 2,660 MW using advanced technologies.

50. Clean air regulations mandating stricter emissions standards are increasing the cost of fossil fuel facility regulatory compliance.

51. Among others, see Steve Clemmer, *The Economic Impacts of Renewable Energy Use in Wisconsin*, Department of Administration, Division of Energy and Intergovernmental Relations, Wisconsin Energy Bureau, April 1994; Howard Geller, John DeCicco and Skip Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies*, American Council for An Energy-Efficient Economy, Washington, DC, October 1992; and *America's Energy Choices: Investing in a Strong Economy and a Clean Environment*, The Union of Concerned Scientists, Cambridge, MA, 1991.

Employment and Expenditure Patterns

Similar to the findings in many of these recent studies referenced above, Michigan can also benefit from expanded activity in the biomass industry. In fact, two recent studies in Maine note that cogeneration retrofits at lumber mills, pulp and paper mills and biomass fueled powerplants provide significant local employment and economic impacts.[52]

Direct effects refer to the on-site jobs created by the expenditures. In the case where new biomass or cogeneration technologies are installed in a manufacturing plant to meet process and electricity needs, the direct effects range from on-site jobs for the contractor crew hired to do the installation and new workers hired to operate the equipment (e.g., boiler engineers, equipment technicians, fuel handlers or additional drivers for hauling residues).

Indirect effects include the support the contractor and facilities receive to carry out the improvements or operations. They include people such as bankers who provide financing, accountants who keep the books, forestry industry workers who collect, process and transport residues (e.g., loggers, chipping contractors and haulers), as well as the manufacturing companies which produce the equipment that will actually be installed or used to collect, process or transport residues.[53]

Induced effects identify those activities that are said to be "induced" by the spending patterns of those people directly and indirectly employed. This refers to money that direct and indirect workers spend at grocery stores, for instance, which hire people to work in the store.

These various types of impacts were noted in the Maine study mentioned above. In one instance, in an effort to upgrade efficiency and seek new forms of income, the owner of a small lumber mill in Searsmont, Maine (typical of many of those in Michigan) installed a 1.2 MW biomass cogeneration system "viewing it as an opportunity to better meet their

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52. Among other studies, see Skip Laitner, Steve Bernow, Marc Breslow, Marshall Goldberg and Jeff Hall, *Energy Choices Revisited: An Examination of the Costs and Benefits of Maine's Energy Policy*, Mainewatch Institute, Hallowell, ME, February 1994; and Jim Connors, *The Wood Fired Electric Generating Industry In Maine*, Maine State Planning Office, an unpublished report, 1993.

53. There are currently a significant number of Michigan firms involved in manufacturing combustion equipment, forestry wood harvesting and wood fuel processing equipment, transportation equipment, providing engineering and design services, and performing retrofits and conversions. For more information see *1993 Biomass Energy Directory* (a directory of equipment and services for the biomass industry), Independent Energy, Milaca, MN; and the Michigan Public Service Commission/Energy Resources Division, *General Bidder's List*, 1994.

needs and add to their bottom line." Offsetting their own electricity needs and selling power to the local utility was viewed as "vital to the operation."

The success of this investment—for the mill, the community and the state as a whole—is reflected in the more than 100 jobs provided to local residents and their 1992 expenditures—of which 99 percent (approximately $4.1 million) were spent in-state. This high percentage of in-state retention is fairly typical of biomass facilities throughout the nation, many of which spend as much as 75 percent or more of total facility operating expenditures on salaries and wages, as was the case in Maine.

Fuel expenditures vary but these typically local purchases can account for upwards of 20 percent of total expenditures as was the case in this small cogenerating lumber mill. The remaining 5 to 10 percent (depending on individual plant expenditure patterns) includes production costs and significant payments for property taxes and fees to local and state governments.[54]

The Maine study notes that "small power producers in Maine have been one of Maine's largest sources of new employment."[55] The significance of the biomass electric industry is further emphasized in the key findings of a recent study on income and job benefits of using wood and other biomass resources to produce electricity in the United States. The study notes, "With much of this activity in the rural sector, biomass power can be a substantial pathway for revitalizing rural America."[56]

Benefit-Cost Ratios

Another means of estimating the impacts of expanded investment in small scale biomass cogeneration is benefit cost analysis utilizing a modification of different benefit-cost tests. These tests are used as the primary criteria to determine cost-effectiveness of utility conservation resource programs.[57] This includes:

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54. Skip Laitner, et. al., *Energy Choices Revisited*, op. cit., page 39. The 1.2 MW Maine lumber mill paid approximately $75,600 for taxes and other fees in 1992 alone. Similarly, the report sites a large pulp and paper mill cogeneration facility which pays approximately $75 million annually for salaries and wages and $6.7 million in local property taxes.

55. Ibid., page 21.

56. See Meridian Corporation and Antares Group Inc., "Economic Benefits of Biomass Power Production in the U.S.," *Biologue*, September/December 1992, page 12.

57. For a more complete understanding of these four tests, see *Economic Analysis of Demand-Side Management Programs*, a standard practice manual published by the California Public Utilities Commission and the California Energy Commission, Sacramento, CA, 1987.

Cogenerator Perspective (participant test) which considers the goal of the business to reduce overall energy costs. Here the net benefit is equal to the energy payments received for power production plus incentives (if any) less the project investment and operating costs.

Utility Perspective (utility test) which reflects the goal of meeting new and existing demand based on cost-effectiveness. In simple terms, the net benefit is equal to the avoided costs of supply less program costs, incentives (if any) and energy and demand payments awarded to cogenerators.

Non-Participant Perspective (non-participant test) which identifies the impacts on the rates that electric utility customers pay. This is equal to the avoided costs of supply less cogenerator payments and program costs.

State Perspective (total resource test) which reflects the net benefits; it equals the energy savings less the utility program costs and the cost of operating and installing the cogeneration facility.

None of the tests described above include a review of what economists refer to as market *externalities*; yet, well-established economic theory teaches that to use resources efficiently all costs must be included in the market price paid for all goods and services. In spite of this, the practice of setting energy prices has largely ignored the environmental costs of producing that energy, resulting in inefficient use of scarce energy resources and in societal costs related to environmental degradation, human health impacts, lost employment and income opportunities.[58]

Although choosing whether or not to invest in biomass cogeneration clearly has externalities associated with the decisions, in this case we evaluate the benefits and costs of an investment in 500 kilowatts (kW) of biomass cogeneration capacity based solely on the four tests noted above. We utilize the cost data from the table below as well as additional input data contained in the following table to yield the results. The analysis assumes utilities provide technical and informational assistance and a rebate program pays $600 per kW of capacity installed.[59]

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58. Some studies have estimated lost employment and income opportunities—resulting from an inefficient use of electricity—costing as much as 2.0 cents per kWh. See "Prefiled Testimony of John A. Laitner," before the Connecticut Department of Utility Control, docket No. 92-11-11, filed on behalf of the City of Hartford, CT, March 1993.

59. This rebate amount provides a one-time lump sum incremental equipment payment to facilities. It is calculated at one-half the utility avoided costs of $0.03 per kWh. The avoided cost estimate is based on information contained in recent Integrated Resource Plans filed by the state's major utilities.

TABLE 6. INPUT DATA FOR BENEFIT COST EVALUATION OF 500 KW OF BIOMASS COGENERATION CAPACITY

Category	Rate
Avoided cost ($/kWh)	$0.03
Retail cost ($/kWh)	$0.053
Utility rebate ($/kW)	$600
Utility admin. cost ($/kW)	$30
Inflation rate	4%
Discount rate	10%

Incorporating a simple model designed to analyze the data in Tables 4 and 6 we generated benefit cost ratios for each (i.e., the present value of benefits divided by the present value of costs) for each of the four tests. A ratio greater than 1.00 means the investment as defined is cost-effective, while a ratio greater than 2.00 is considered highly cost-effective. On the other hand, a ratio of less than 1.00 indicates that costs exceed the benefits.

Based on this analysis, the following table shows that a $600 rebate per kW to an existing biomass facility can be cost-effective for three of the tests (highly cost-effective for two). Only the non-participant test is shown not to be cost-effective. Similarly, the analysis reveals the same investment for facilities currently burning natural gas, is highly cost-effective from the utility and participant's perspective.

This analysis reinforces the original economic analysis—that investments in biomass cogeneration are attractive and economical for the existing wood-fired facilities—in spite of relatively low avoided costs. Utility support (e.g., information programs, assistance with financing or other services) can help ensure these investments are realized and the infrastructure for the small scale power industry matures before significant new supply is needed and avoided costs rise.

TABLE 7. BENEFIT-COST RATIOS FOR INVESTMENT OF 500 KW BIOMASS COGENERATION CAPACITY

	Biomass Facility	Natural Gas Facility
Cogenerator perspective	2.62	2.51
Utility perspective	3.54	3.54
Non-participant perspective	0.49	0.49
State perspective	1.27	1.21

Similar to the investments in the biomass facilities, natural gas investments, are highly cost-effective from the cogenerator and the utility perspective, and moderately cost-effective from the stat's prospective. However, like the biomass facility, the non-participant perspective reflects a very low benefit cost ratio of 0.49. Even a larger rebate than that assumed here (feasible since the utility benefit cost ratio is so cost-effective) will make it more attractive to the participant, yet still will be unattractive from the non-participant perspective.

In either instance, the cogenerator benefit-cost ratio of 2.51, although cost-effective, may not be an attractive investment for the natural gas facility decision makers. This makes sense given the higher payback period. In instances like these, losses (i.e., low benefit-cost ratios) for the non-participants and/or state, speak to the need for diversification and the need to promote other resources such as demand-side management programs that these non-participants can participate in. If other programs are put in place for the non-participants, (e.g., demand-side management programs which allow them to reduce consumption), they will have the ability to offset any potential rate increases.

MARKET PENETRATION FOR BIOMASS COGENERATION

To further assist policy makers in understanding the economic potential for small scale biomass cogeneration in Michigan we were asked to estimate the market penetration. Market penetration is not merely a reflection of those facilities which have the economic potential. There are still other factors such as boiler life, retooling cycles, experience of others in the industry, and other less tangible considerations which affect the actual decision to proceed with a retrofit or conversion. These include: the ability to obtain financing for up front costs, perceived need for new environmental permits, access to information, investment risks and a host of other barriers, real and perceived.[60] The market penetration is therefore only a subset of those facilities which have economic potential and are likely to invest in cogeneration.

Methodology

We began by attempting to gather information on current facilities cogenerating with biomass fuels. According to a recent assessment of renewable capacity in Michigan, 255.3 MW of biomass capacity from wood are currently on line (i.e., sold to or generated by utilities).[61] Unfortunately, we found little information exists on the number, capacity or location of facilities currently utilizing biomass cogeneration systems to meet their process needs and generate electricity.

Based on the responses from the DNR/FMD survey, it appears there may be a total of 15 wood products industry manufacturers cogenerating with wood.[62] Further investigation reveals there are at least 2 large pulp and paper mills, a large glass manufacturing facility and at least 6 large mills also cogenerating with biomass residues (several of which are no doubt included in the on-line capacity noted above).[63]

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60. For a more detailed discussion of barriers and constraints affecting the target industries see the following section of this report.

61. See Jan Hamrin and Nancy Rader, *Investing In The Future: A Regulator's Guide to Renewables*, National Association of Regulatory Utility Commissioners, Washington, DC, February 1993, page D-8.

62. This estimate is based on projections for the entire survey population using coefficients developed from the number of respondents per county derived from the DNR survey database cited earlier. The survey responses did not indicate how much electricity is being generated or whether it is being used to meet in-house needs solely or if excess electricity is being sold to local utilities.

63. This information is based on a review of various documents and communication with the Michigan Department of Natural Resources. See Michigan wood combustion facilities found in the *Biomass Energy Facilities, 1988 Directory of the Great Lakes Region*, op. cit; and Wood Energy Facilities in *Wood*

To supplement the data compiled from the DNR/FMD survey we contacted biomass cogeneration industry representatives, project developers, and other experts in the biomass field to get their opinions on market penetration and those factors which impact the industry.

We noted that potential electricity cost savings, while attractive to many, are often not the most significant motivator by themselves. Other factors, such as the need to reduce emissions or achieve productivity enhancements, acceptance by industry peers, combined with retooling cycles are often more substantial motivators of change.[64] We then found that the industries in the manufacturing sector retool their boiler equipment approximately every 25 years.[65]

With this retooling cycle as our basis for estimating market penetration, we then assumed an equal number of facilities will retool each year. With no other constraints the market penetration would be 4 percent annually for those facilities with economic potential.[66]

However, based on the relatively small existing biomass cogeneration penetration (representing an early stage of diffusion)[67] and the barriers expressed by the survey respondents, we refined this annual penetration estimate by 50 percent to reflect a more conservative penetration rate of 2 percent annually. This rate assumes little is done by

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Products in Michigan: Mills and Manufacturers op.cit.

According to a personal communication with Lynn Fiedler, Michigan Department of Natural Resources, Combustion Process Unit, in June 1994, there is no list of biomass cogeneration facilities available. However, Ms. Fiedler noted that there are large wood burning electricity generating facilities in Hillman, McBain, Lincoln, Cadillac, Mt. Pleasant and Flint. No additional information was provided on these facilities although it appears they may be wood-fired power plants rather then cogeneration facilities.

64. See R. Neal Elliott, *Electricity Consumption and the Potential for Electric Energy Savings in the Manufacturing Sector*, American Council for An Energy-Efficient Economy, Washington, DC, April 1994; and The Center for Applied Research and Economic Research Associates, *Expanding Energy Savings by Accelerating Market Diffusion of Efficient Technologies: Three Case Studies*, prepared for the U.S. Department of Energy, Office of Financial and Technical Assistance, February, 1992.

65. See the earlier discussion, in the methodology section of the previous chapter, referring to hurdle rates and retooling cycles.

66. Theoretically, if 4 percent of the industries retool each year (for 25 years), at the end of that period all facilities will be retooled and the process will begin again.

67. Diffusion refers to the gradual process of acceptance of a technology in the marketplace. For more discussion on this process see E.M. Rogers, *Diffusion of Innovations*, Third Edition, Free Press, NY, 1983; and Adam B. Jaffe and Robert N. Stavins, "The Energy Paradox and the Diffusion of Conservation Technology," a paper prepared for the National Bureau of Economic Research, Conference on Economics of the Environment, Cambridge, MA, December 13-14, 1991.

utilities or the state's policy makers to further encourage biomass cogeneration but assumes awareness for landfill disposal issues and environmental regulation continues to rise.

Similarly, this scenario assumes the cost and availability of biomass residues remains relatively constant and continues to provide the same economic potential for those facilities (all wood-fired retrofits) noted earlier as having economic potential.

The MEOS study uses a methodology for estimating market penetration which comprises a diffusion model tied to an increasing rate of return (similar to the hurdle rate mentioned earlier). Plotted on a graph this method assumes a lag in market penetration at the minimum rate (20 percent), with sharp increases as the return on investment increases, and finally leveling off to reflect that a significant percentage of the target population has already been reached.[68]

Although hurdle rates play a key role in much decision making, we assume meeting the hurdle rate noted above (a minimum of 13.5 percent) provides the threshold incentive for facilities to invest in cogeneration, and the most important consideration becomes diffusion within the retooling cycle. Given the more conservative penetration rate we have assumed and the numerous uncertainties in the marketplace, our methodology reflects a straight-line growth in penetration. We believe this is a reasonable estimate for biomass cogeneration given the lack of information on facilities in the target population.

With this base case market penetration established we then once again reviewed those factors which potentially constrain this potential (i.e., barriers and constraints) to derive a revised market penetration. We assume the issues such as lack of up-front investment capital (the most common number-one-ranked barrier to biomass cogeneration in the DNR/FMD survey) and financing, would be addressed by incentives such as utility rebates and easier access to loans, such as those offered by the Small Business Association (SBA). We also noted that more than one-third of those secondary wood products manufacturers responding to a question regarding the age of their boilers stated that their boilers were over 15 years old, and some as old as 70 years.[69]

During the five year period (1995-2000) we assume more information will become available, utility programs (e.g., informational services and other incentives) will start to arise, as will better access to financing (responses to some of the perceived barriers and constraints), resulting in accelerated diffusion of biomass technologies beginning in

68. See *MEOS Commercial and Institutional Cogeneration*, op. cit., page 5-5.

69. In spite of these reports of aging boilers and increasing air quality regulations, few of the respondents provided information on the expected year of replacement.

the year 2000. The peer acceptance combined with the retooling will increase penetration by an additional one percent annually for the target industry population.

We also assume awareness for landfill disposal issues and environmental regulation continues to rise and the cost and availability of biomass residues remains relatively constant.

MARKET PENETRATION

Based on the analysis of those facilities with economic potential the base case market penetration of small scale biomass cogeneration in Michigan reaches 32 percent by the year 2010. Penetration begins in 1995 with 2.4 MW and reaches a total of 39 MW by the year 2010.[70] As the table on the following page indicates, the market penetration (as noted above) follows the retooling cycles of the industries.

TABLE 8. BASE CASE MARKET PENETRATION FOR BIOMASS COGENERATION

	1995	2000	2005	2010
Capacity (MW)	2.4	14.6	26.8	39.0
Generation (MWh)	13,792	82,754	151,716	220,678

Source: The estimates are based on calculations by Economic Research Associates using those facilities identified as having economic potential.

An accelerated market penetration for small scale biomass cogeneration is reflected in the table below. Penetration remains unchanged from the base case between 1995 and the year 2000 (above) while programs are being put in place and diffusion is occurring. However, beginning in the year 2000, the penetration accelerates to three percent

70. Reflecting a broader perspective on future growth in the nation's large scale direct combustion industry (i.e., utilizing wood and agricultural residues), Scott Sklar, Executive Director of the National Bioenergy Industries Association (previously the National Wood Energy Association) believes "[T]he industry is not capable of growing beyond 15%/year from 1993-1995, and not over 25%/year from 1996-2000." See Scott Sklar, "Biomass and Federal/State Tax Policy," *Biologue*, June 1992, National Wood Energy Association, Washington, DC, page 10.

annually. Penetration increases to 32.9 MW in the year 2005 and a total of 51.2 MW by the year 2010. This revised scenario represents an increase in biomass cogeneration capacity (compared with the base case capacity) of almost 23 percent by the year 2005 and 31 percent by the year 2010.

TABLE 9. ACCELERATED MARKET PENETRATION FOR BIOMASS COGENERATION

	1995	2000	2005	2010
Capacity (MW)	2.4	14.6	32.9	51.2
Generation (MWh)	13,792	82,754	186,192	289,632

Source: The estimates are based on calculations by Economic Research Associates using those facilities identified as having economic potential.

BARRIERS TO BIOMASS COGENERATION

The incentives, technical feasibility and economic justification for expanding the use of small-scale cogeneration systems in the state of Michigan are discussed in other parts of this report. The purpose of this chapter is to begin discussion of the barriers and constraints to small-scale biomass cogeneration.

The first section provides a discussion of the barriers as perceived by those who own and operate candidate facilities as well as those who are in the business of supplying fuel, equipment or technical expertise to these facilities. A discussion of barriers identified in other studies is then presented, and finally a brief discussion of what is being done in Michigan and other states to overcome identified barriers.

PERCEPTIONS

As a practical matter, if a facility operator perceives a situation or condition to be a barrier to implementation of cogeneration at that facility, that barrier is very real, whether or not the perception is accurate. Thus, regulators and analysts can perform their technical, economic and other analyses, but if they do not accurately capture the perceptions of the people who would potentially use cogeneration systems, they are likely to get only part of the picture. The purpose of this section is to discuss the perceptions of operators of candidate facilities and others in the biomass and/or cogeneration business in Michigan and elsewhere to get a feel for what they think are the significant barriers to fuller implementation of the potential.

The first part describes the outcome of a survey conducted by the Forest Management Division of the Michigan Department of Natural Resources (DNR) in 1993. The second part presents the findings of a follow-up survey performed in early 1994 on behalf of the PSC. A brief summary of the combined results is then presented.

DNR Survey

In October of 1993, the DNR mailed a 27-question survey to 1,687 secondary wood products manufacturers in the state. The purpose of the survey was to collect information regarding the volumes and dispositions of wood and paper residues generated by these facilities. The first 19 questions on the survey asked general information about the company and more specific information about the wastes it produces, the disposition of those wastes, and whether or not the company would be interested in other options for disposal of the wastes. The information collected from the 477 companies that responded to these questions was summarized in the *Michigan Wood and Paper Residue Study*, published in March of 1994.[71]

The final eight questions of the survey asked whether or not the company was interested in energy efficiency or cogeneration systems, what types of payback periods companies would require to consider installing such systems, and what they thought were the most significant barriers to the company installing such systems.

Of these last questions, number 21 asked specifically whether the company would be interested in a biomass cogeneration system and, if so, how many years they would require the investment to be paid back in. Question 24 presented a list of potential barriers (including an "other" category) and asked the respondent to number (i.e., prioritize) those barriers which are most important for their business. The information collected in response to these two questions is discussed in this section.[72]

Question 21 asked "Would you be interested in a cogeneration system?" The options were "Yes," "No," and "Don't Know." A total of 345 provided a response to this question. Of these, 76 indicated that they would be interested, 177 said "no," and 92 did not know.

If the response to question 21 was "Yes," the respondent was asked what length of payback period they would require in order to invest in such a system. The response to this portion of the question is summarized in the table below. As can be seen, fully two-thirds of the respondents would require a payback period of between three and five years. An additional 16.0 percent require a payback period of two years. The remaining 19.0 percent either left the question blank or would settle for six or more years payback.

71. Carolyn J. Randall, *Michigan Wood and Paper Residue Study, Secondary Wood Products Manufacturers*, op. cit. The author reports that the respondents were a representative sample of the survey population based on industry type and location by county.

72. Although the information in the remaining survey questions is outside the scope of this particular discussion, in general we observed: approximately 18.0 percent of respondents noted that they utilized a boilers in their operations while only 2.3 percent had cogeneration equipment; 36.0 percent of respondents were interested in information on energy efficiency options for their business; when asked about barriers to energy efficiency, lack of money and inadequate return on investment were the two biggest barriers, together approximately 45.4 percent of the respondents noted these; when asked if respondents were interested in seminars, workshops or other options, less than 3.0 percent said yes to any of the options; and finally, when asked if they could be contacted further, almost half responded yes.

TABLE 10. PAYBACK PERIOD SOUGHT BY MICHIGAN COMPANIES CONSIDERING BIOMASS COGENERATION SYSTEMS

Payback Period (Years)	Number of Responses	Percent of Responses
2	12	16
3	18	24
4	6	8
5	24	32
6-9	5	5
10+	2	2
No Response	9	12

Source: Data derived from Michigan DNR/FMD survey responses.

Question 24 stated that "Several factors have been identified as potential barriers to cogeneration. Please indicate the barriers you think are more important for your business, by numbering up to three of these options--from 1 to 3--where 1 is the biggest barrier to you." The options that were provided were as follows:

1 Storage space for equipment, fuel
2 Increased regulatory scrutiny
3 Don't know who to trust
4 Takes too much labor to operate
5 Easy financing not available
6 Don't trust cost savings figures of vendors/engineer firms
7 Environmental permits
8 Lack money to pay for equipment
9 Don't know what options are available
10 Would disrupt business during installation
11 High utility stand-by rates
12 Other

Blank spaces were left and respondents were encouraged to describe "other" barriers that were important for their facility.

A summary of the responses, identifying the frequency in which each response received an importance rating of 1, 2, 3 or no number, appears in the table below. A total of 260 of the returned surveys included answers to Question 24. Of these, 40 identified barriers, but did not include a number with their responses.

TABLE 11. RESPONSES TO IDENTIFIED BARRIERS TO BIOMASS COGENERATION, IN PERCENT

	Barrier	1	2	3	No number
1	Storage space	10.5	9.6	8.8	9.3
2	Regulatory scrutiny	6.4	16.9	18.1	16.9
3	Don't know who to trust	0.5	1.7	6.3	5.1
4	Labor to operate	3.2	6.8	8.1	4.2
5	No easy financing	2.7	7.9	5.0	7.6
6	Question savings data	3.6	5.6	6.9	3.4
7	Environmental permits	12.7	16.4	13.8	17.8
8	Lack up-front costs	28.6	10.7	9.4	16.1
9	Don't know options	12.3	13.0	13.8	11.0
10	Disruption of work	0.5	4.5	1.3	4.2
11	Utility stand-by rates	1.4	1.1	5.0	2.5
12	Other	17.7	5.6	3.8	1.7
	Total	100.0	100.0	100.0	100.0

Source: Calculated from responses to the Michigan DNR/FMD survey. Totals may not add due to rounding.

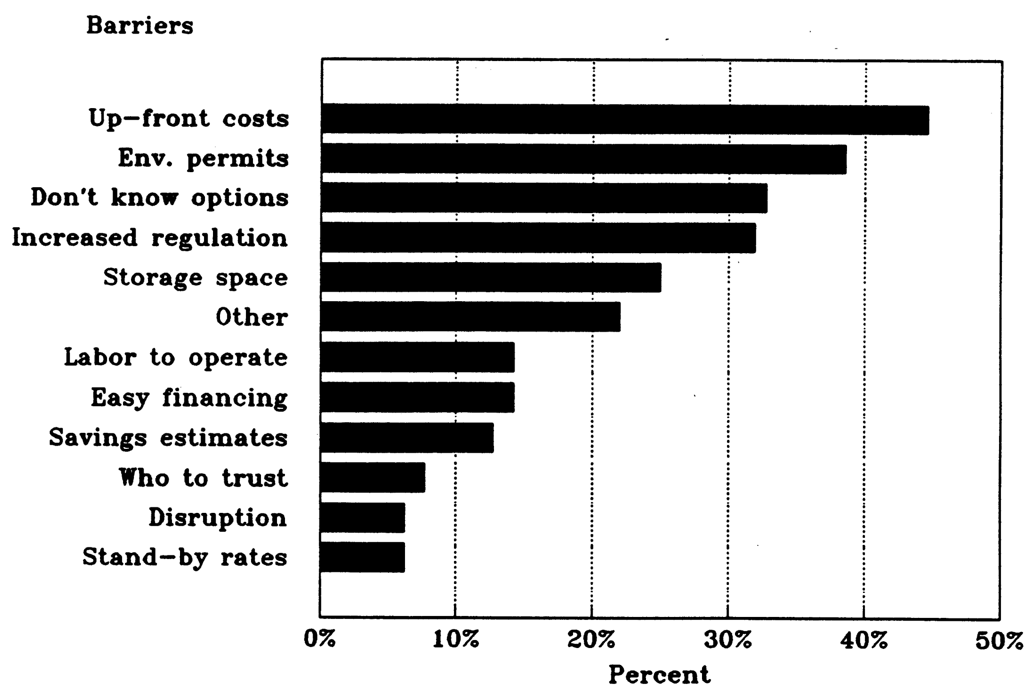
There are a number of points worth noting about the trends in the table above. First, the most common number one ranked barrier, identified by nearly 29 percent of the respondents, was a lack of up-front costs. This was followed by "other," environmental permits, lack of knowledge of the options, and a lack of storage space for fuel and equipment, each identified by between 10 and 20 percent of the respondents. Relatively speaking, the increased regulatory scrutiny, labor to operate, mistrust of savings projections, availability of financing, utility stand-by rates and disruption of business during installation were not as important as first-ranked barriers.

A second point worth noting, however, is how the identified barriers change in importance as other barriers are addressed. For instance, lack of up-front capital was the first most important barrier to nearly 29 percent of the respondents, but ranked second by only about 11 percent and third by only about nine percent.

In contrast, increased regulatory scrutiny was listed as first most important barrier by only about six percent of the respondents. However, as other barriers such as cost are addressed, the regulatory scrutiny barrier appears to increase in importance. It was picked as the second most serious barrier by nearly 17 percent of the respondents and as the third most important barrier by over 18 percent. Not knowing who to trust, labor to operate systems, not trusting cost savings figures, and utility stand-by rates also appear to become more important as other barriers are addressed.

Figure 3 below offers another instructive way of looking at the information obtained from responses to Question 24. It shows the number of times (in percent) each barrier was identified by any respondent, regardless of ranking. Some of the figures given by this tabulation are somewhat surprising, given the information in the table above.

FIGURE 3. PERCENT OF RESPONDENTS LISTING EACH BARRIER



Source: Michigan Department of Natural Resources.

For instance, a total of nearly 45 percent of all respondents listed "lack of money to pay for equipment" as a major barrier. "Environmental permits" and "Don't know what options are available" were the second and third most cited barriers, with 39 and 33 percent, respectively. These figures appear to be consistent with the results as reported in the table above. It was somewhat surprising, however, that over 32 percent listed "Increased regulatory scrutiny" given that only six percent of the respondents ranked it as the number one barrier.[73]

Another figure worth noting, given its relative lack of importance in the rankings above, is that 25 percent of all respondents stated that "storage space for equipment and fuel" was a major barrier. Finally, we see that while 45 percent indicated lack of up-front

73. Exactly what this barrier means in the minds of respondents is also something that should be considered. Presumably, since "environmental permits" was listed as a separate barrier, at least some portion of the respondents listing this barrier must have had non-environmental regulations in mind. If not, then the environmental regulations concern would become the single largest barrier identified in the survey. Future surveys should be designed to draw a distinction in this area.

capital was a major barrier, less than 15 percent listed obtaining financing and even fewer listed cost-savings data as major barriers.

Approximately 22 percent of the respondents listed and described "other" barriers to installing cogeneration systems. The descriptions of these "other" barriers are also instructive. The overwhelming majority of these comments were to the effect that the company was too small and/or it did not produce enough fuel to feed a boiler. The next most common statement was that the facility was rented or leased and that landlords or insurance companies would not allow such a system.

A number of respondents noted prohibitive initial costs, excessive payback periods, or technical reasons (not enough steam capacity in current system) as barriers as well. Some noted that they did not want to forego current income from selling the fuel that they produced. Finally, there were several mentions of state and county environmental ordinances that were difficult or impossible to meet, and one statement that the Michigan Occupational Safety and Health Administration (MIOSHA) was a "real problem" in this regard.

The information presented above contains some interesting insights into potential barriers to small-scale cogeneration facilities. However, it is somewhat self-limiting in that opinions were only sought from facilities that potentially could benefit from such systems, and because respondents were presented with a predetermined list of barriers. Although about 22 percent of the respondents suggested additional barriers, the design of the survey may have restricted the type and detail of information obtained.

Therefore, a follow-up survey was conducted as a part of this current study. The results of that survey are discussed in the following section.

Public Service Commission Follow-Up Survey

In order to provide additional insight into the barriers and constraints to small-scale biomass cogeneration, Economic Research Associates conducted an informal survey on behalf of the PSC, during March and April of 1994, to build on information contained in the DNR/FMD survey. This was a telephone survey of government personnel responsible for regulating biomass cogeneration systems; manufacturers of biomass cogeneration systems; contractors who study, design and install biomass cogeneration systems; banks and other institutions that might be called on to finance such systems; wood fuel processors and brokers; and some of the facilities that responded to the DNR questionnaire discussed above.

The focus in selecting regulators for interview in this process was on those in the state of Michigan and included representatives of the DNR and the PSC. They also included representatives of the U.S. Environmental Protection Agency (U.S. EPA) responsible for facilities in Michigan, and regulators from other states that are responsible for overseeing biomass cogeneration facilities. Equipment manufacturers interviewed were from all parts of the country. The contractors interviewed were all east of the Mississippi, and most were in the Great Lakes region or in New England. Financial institutions and wood fuel processors and brokers were all from the state of Michigan, as were the facilities that are candidate sites for cogeneration.

Respondents were asked general questions about their businesses in order to get some perspective for more fully understanding their perceptions. They were then asked what they saw as the barriers and constraints for facilities that could most benefit from small-scale biomass cogeneration. This approach encouraged respondents to identify and describe barriers that they saw rather than simply ranking a predetermined list of barriers. This fact, combined with the inclusion of professionals who have different perspectives on the industry (such as fuel brokers), resulted in the identification of barriers that were not identified in the DNR study.

One point should be kept in mind when reviewing the results of this process. Many of the respondents are in the business of working with utility-scale (30-70 MW) plants. The barriers these people perceive are accordingly focused on facilities of that size. Many of these barriers, however, also affect the smaller facilities that form the focus of this study. Where relevant, these differences will be noted in discussing the results.

The information collected from the survey is summarized below. The responses are divided into the following categories: the difficulty of getting reliable information regarding the potential of small-scale biomass cogeneration; fuel supply, including the questions of proximity of source to end-user, and competition for quality fuel; up-front costs and financing; economies of scale, payback periods, and destination of power to be produced; environmental regulations; other governmental regulations and utility policies; and other issues. Where appropriate, distinctions are made between groups offering conflicting responses.

Overall Lack of Information. Probably the most striking result of this survey was that most of the information that is easily available to facility operators at present is not focussed on the small-scale facilities that we are studying here. For instance, one of the sources for identifying contractors and consultants for this survey was the General Bidders List and the Performance Contracting Bidders List provided by the Michigan Public Service Commission/Energy Resources Division. As part of this survey, Economic Research Associates contacted about half of the companies on these lists that indicated they worked in "cogeneration" and/or "wood/biomass conversion."

The overwhelming picture that emerged when talking to these consultants and vendors was that the small-scale systems being studied in this report are not economically feasible. There were definitely exceptions to this position, and those that are in the work of designing and installing such smaller systems feel strongly that they are economically beneficial both to the host facilities and to the economy of the state as a whole. However, from the perspective of a facility operator who wants more information, two or three calls to random firms on these lists are likely to produce immediate discouragement from proceeding any further, on economic grounds alone.

Brokers and larger facility operators were also concerned about the lack of available information regarding the quality and quantity of obtainable fuel supplies. At least one contractor noted that this was of concern to financial institutions as well. Follow up calls to financial institutions in the state confirmed this opinion.

One final observation in this regard is that if the state of Michigan is going to be serious about promoting such facilities, then consultants, contractors, vendors, financial institutions and regulators that work specifically with these smaller systems must somehow be identified and made accessible to operators of potential host facilities.

Fuel Supply: Shortage or Glut? Questions regarding fuel availability were far and away the most mentioned concern during this survey. Concern on this point generally fell into two categories: (1) how much fuel is available, which is addressed here; and (2) the quality of fuel and competition for material, which is addressed in the next point, below.

The question of whether or not the fuel supply exists to meet the demand was addressed by every broker interviewed, and by many of the other respondents as well. What was most significant in the responses was that no clear opinion emerges as to whether or not an adequate fuel supply exists in Michigan to meet the potential demand.

Many respondents felt that the supply was being used to its full potential, others stated that there is currently a shortage of fuel available, and yet others noted that there are still large quantities going unused. This lack of a clear picture regarding what is probably the most important component in determining the potential of biomass cogeneration in the state is a key point that must be addressed if significant progress is to be made.

Despite this lack of clarity, however, there was agreement on several points regarding fuel supply. First, there appears to be a potentially large seasonal variable to the availability of fuel. It was noted by several respondents that this past winter was particularly difficult due to extreme weather conditions. Some businesses that normally supply their own fuel or have regular suppliers were thus relying on the fuelwood market to supplement their supply.

The competition for the available fuel drove prices up, and many of the brokers had difficulty meeting demands. Even in years with milder winters, more fuel-grade byproducts are coming out of the forests during the summer than the winter months. (Bark was specifically mentioned in this regard.) During the summer months, this tends to increase the total supply during the summer and exerts downward pressure on prices paid to brokers who supply fuel to facilities.

There was also agreement, even between those who see a glut and those who see a shortage, that the major supplies of fuel are not reasonably proximal to the facilities that use the fuel. The half-dozen or so major industrial and utility biomass plants in the state were mentioned repeatedly in this regard. It was felt that some of these plants were located without regard to fuel supply, and that when they have come on line during the past few years they have "thrown money at the problem," disrupting local supplies and causing facilities that used to have their needs met locally to have to seek supplemental fuel from further away.[74]

In looking at the geographic dispersion of the respondents, this problem seems largely to be one of matching suppliers with users. There are several instances of suppliers shipping fuel across the state to locations that have facilities in adjacent counties reporting fuel gluts. There are several instances of facilities importing fuel from Ohio and Wisconsin, and other facilities exporting fuel to the same states.

One facility operator in the lower part of the state foresees the potential need to start importing fuel from Canada soon. Nearly every respondent that mentioned this point agreed that the infrastructure needed to move all this fuel around is not in place and that the economics of establishing such a system appeared to be prohibitive given current conditions.

A final note should be mentioned regarding the perspective from which these opinions were offered. Most of the respondents that had concerns mentioned above were large users or brokers of fuel. It was clear from others, however, that these concerns also apply to small facilities that need to supplement their fuel supply or that sell or must otherwise dispose of excess waste generated at their sites.

Fuel Supply: Competition for Uses. A second point regarding fuel supply was the question of fuel quality as it relates to other uses. While in the broader sense, the resolution of this issue relates to the fuel supply questions discussed above, it was specific enough and mentioned by enough people to warrant its own discussion. The two main issues mentioned in this regard can be described as a problem of defining "waste" versus "scrap" material, and the issue of source separation.

The "waste" versus "scrap" discussion has significant ramifications for biomass cogeneration and for other aspects of Michigan's economy. As both solid waste disposal

74. Two of the most recent plants, the plant at Cadillac and the planned Genesee plant near Flint, were specifically mentioned in this regard by several respondents.

and virgin materials have become more costly during the recent past, many companies are now "mining" the waste stream for materials that can be used as input into their processes and products. This phenomenon is a contributor to the increase in use of biomass fuel. However, there are a number of other uses for woody scrap material that result in a higher value-added output for local and regional economies.

For instance, with old growth timber supplies dwindling, mills are now using smaller trees (and more of each tree they get) for the production of lumber. Particle board, strand board, and other manufacturers of wood composites are utilizing sawdust and other available wood wastes to help offset the higher costs and limited supplies. This puts a dent in the supply of smaller trees and mill scraps that were once chipped for paper or other products. In part to offset this problem, the practice of recycling paper has increased dramatically. In addition, however, chips for input into paper products are also obtained from manufacturing facilities and other facilities that used to have scrap that they had to dispose of in other ways. Some of this scrap is also manufactured within the state of Michigan into animal bedding, landscaping material and other products.[75]

There is a large supply of "scrap" that can be used in these types of processes, and there is a large quantity of "waste" that cannot be used in many of these products. The latter category includes some portion of the waste left on the forest floor during logging operations, as well as sawdust and sanderdust, bark, and other byproducts of secondary wood manufacturing. The problem that many respondents of the survey identified is that there are a number of facilities burning scrap, which has a potentially higher value-added use in other products, while there are still large quantities of wastes available that currently have no other uses other than for fuel.

Addressing this problem will provide benefits to Michigan's economy, not only in helping to reduce solid waste disposal problems, but in freeing up additional materials that can be manufactured into useful products.

A second factor that relates to the quality and quantity of fuel available is the issue of source separation. Although most small-scale facilities produce a homogenous waste supply, there are some facilities and a number of other potential fuel suppliers (such as urban areas) that for various reasons have trouble with source separation. In other words, the waste that is a good potential fuel source is mixed with other wastes that cannot be burned (such as painted wood, or other materials such as construction materials or plastics). Once the materials are mixed, it is prohibitively expensive to sort them again.

75. See the earlier discussion of "Other Demand for Biomass Residues" in the Biomass Waste Inventory section of this report.

It was felt by many respondents that fuel supplies could be dramatically enhanced if facility operators were educated about the benefits of not mixing wastes, and if other processes were modified in order to make source separation easier. (An example given several times was that if buildings were dismantled piece by piece and the parts kept separate, rather than run-over by bulldozers and piled up, urban areas might divert currently land-filled demolition waste materials into a significant supply of fuel.)

Economics: Initial Costs and Financing. From the point of view of most facility owners, one of the major obstacles to getting into small-scale biomass cogeneration is the cost of installing the system. In fact, some of the candidate facilities that had already explored the potential for installing such systems and had studied some of the other potential barriers listed initial cost as the number-one barrier. For many, this remains true even when it can be demonstrated that the payback period will be short and the long-term benefits significant. (This finding is consistent with the DNR findings discussed above.)

One contractor noted that lending institutions they have worked with require evidence of a long-term fuel supply at fixed or stable prices as a condition of providing financing for biomass energy systems. If a facility cannot supply all of its own fuel or obtain a long-term fixed price contract for supply, they are required to put up a sizeable cash deposit (up to $0.5 million per MW).[76] Other contractors and larger facility operators noted the costs of obtaining all of the requisite permits and of negotiating power purchase or stand-by rate agreements[77] with utilities as significant up-front investments of time and money.

Economics: Will the Investment Pay Off? It was interesting to note in conducting this survey that most of the contractors and several equipment manufacturers said they would not touch a system any smaller than about 30 MW because the economies of scale do not exist. Others thought that a minimum of 40 to 60 MW were necessary to provide a return on investment. Several contractors noted that they have lucrative arrangements for designing and operating facilities for utilities and were not interested in any project that might be seen as competing with a utility, including helping a small facility generate some or all of its own electricity.

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76. The financial institutions interviewed during this process confirmed that a guaranteed fuel supply would be a key factor in determining eligibility for and the amount of a loan. However, they suggested that this would be a question of whether or not the loan would be approved and not something that would be resolved by a deposit.

77. Power purchase agreements generally apply only to the larger facilities that produce more power than they can use on site, and cover all terms of sale of that power to a utility. Stand-by rate agreements are generally needed by all facilities that generate their own power. They cover the terms and conditions under which a utility will provide back-up or emergency power to a cogeneration facility during periods when the facility is unable to meet its own power needs.

It should be noted that most of the people giving these responses are in the business of designing, building and/or operating facilities for large-scale Independent Power Producers (IPPs) under the Public Utilities Regulatory Policies Act of 1978 (PURPA).[78] From the perspective of these respondents, selling power back into the grid was the only reason to have such a system and the only way to make it pay for itself.

It should also be noted that there were respondents who strongly disagreed with the positions regarding size restrictions cited above. There were a few contractors, some vendors and some facility operators who recognized that the installed incremental costs of adding a generator to an existing boiler system were relatively small compared to building a large electricity producing system designed to generate electricity first and capture useful steam second.

With this perspective, and with additional factors added to the calculations (such as the avoided cost of waste disposal and purchasing electricity, and looking at O&M costs incrementally rather than solely as a cost of producing electricity), small systems designed to offset on-site power needs are seen by some as economically justifiable.

Even those with this perspective, however, stressed that for such a system to provide a reasonable payback, the facility would have to be located in the service territory of a friendly utility (if not for power purchases, at least for stand-by rates) that had relatively high electricity rates.

Environmental Regulations. Larger facility operators, consultants associated with them, and fuel brokers all noted that a major concern was stringent environmental regulations. While most recognized that the technology currently exists to meet those requirements, many were distressed that the regulations vary from state to state and even between counties within states. Others noted the strong perception that the environmental regulations seem to be a moving target, with multiple jurisdictions constantly "changing the rules."

Several respondents noted apparently conflicting environmental regulations. For example, currently, both burning coal and land-filling waste wood are being discouraged. Burning more wood for energy seems to be a solution to both problems. However, some jurisdictions appear to be discouraging this activity as well. (Both counties and regional

78. PURPA was created to provide access to utility services for cogeneration and other small power production facilities. The act established a process whereby utilities would be required to interconnect with these facilities, purchase the power they produced at "just, reasonable, and nondiscriminatory" rates, and provide them with backup power. The power purchase rates are set by regulatory bodies within each state, and are generally pegged to the avoided costs for the utility in question. For more detail see the act itself at 16 U.S.C. 2601 et seq., or a summary in James L. Easterly and Michael Z. Lowenstein, *Cogeneration From Biofuels: A Technical Guidebook*, op. cit., page 7-5.

offices of state agencies were mentioned in this regard.) In addition, the sheer number of federal, state, and local agencies that could become involved in the air, water, solid waste and land-use issues around such a facility was overwhelming to some respondents.[79]

Finally, small facility operators that currently have boilers on-line believed that they had most of the environmental permits that they would need if they were to add generators to their systems without significantly increasing the size of those systems. If this were the case, environmental regulations would not be a significant barrier. However, several were not sure that was the case and did not know who to contact to confirm whether or not it was accurate.[80]

Other Government and Utility Policies. No respondent in this survey mentioned MIOSHA as a significant obstacle to small-scale biomass cogeneration. However, several noted confusing, conflicting, and non-existent tax regulations and incentives[81] as one more detail that had to be dealt with en route to bringing a system on line.

Perceived utility attitudes and willingness to work with small facilities on these types of projects also appear to be significant obstacles to implementation. Respondents who mentioned the topic rated the two major investor-owned utilities in the state in this regard. It was noted that Detroit Edison has a reputation for being openly hostile, or, at best, indifferent to facilities proposing such systems in their service territory. Consumers Power Company has a reputation among respondents who broached the subject as being "not thrilled about the idea" or "doing nothing to encourage it."

It should be noted that, whether or not these opinions reflect official utility policies or actual practices, if operators of facilities perceive utilities in this way then this is a very real barrier. It should also be noted that these opinions do not only affect facilities that wish to sell power to utilities. Most facilities that have cogeneration systems must still work with utilities in order to meet their needs for back-up or supplemental power.

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79. One contractor noted that they spent four years and nearly $4.5 million to get the 28 permits required to build a 70 MW wood-fired plant that just came on line in another state. While most of the facilities we are concerned with in this study are very much smaller and already have many of the necessary permits and infrastructure in place, accounts of extensive regulatory requirements like this do not help encourage others to enter the market.

80. Personnel from the Michigan DNR and the U.S. EPA confirmed that, in general, adding a generator to an existing system would not impose additional environmental constraints on a facility provided the addition did not significantly increase the fuel usage of the existing system.

81. These comments no doubt refer to provisions of Public law 102-486, *The Comprehensive National Energy Policy Act of 1992*, 106 Stat. 2776-3133 (known as the Energy Policy Act), which set up financial incentives for biomass facilities subject to appropriations by Congress, and have yet to appear.

Other Issues. For the most part, there were very few concerns of a technical nature. Most of the survey respondents understood that the technology exists to make small-scale systems work.
Several respondents noted that most of the issues are matters of perception and that once the issues are understood they can be easily overcome.

Summary of Perceived Barriers

Both the DNR survey and the follow-up survey on behalf of the PSC identified up-front costs of installing systems, concerns regarding environmental regulation, and a lack of information (including difficulty in finding what information is available) as major barriers to increased implementation of small-scale biomass cogeneration in the state of Michigan.

In addition, the DNR study identified facility size, both in terms of the ability to fuel and operate systems and in terms of the physical plant size, as a major barrier for some potential host facilities. The follow-up survey indicated that other potentially significant barriers exist with regard to quality and quantity of fuel available in Michigan.

BARRIERS IDENTIFIED IN OTHER STUDIES

Numerous studies on various aspects of biomass power production in the United States have been conducted during the past ten years. Although few specifically sought to identify and discuss barriers to small-scale cogeneration operations such as those being studied here, many do discuss relevant barriers in the context of other issues. The purpose of this section is to briefly outline some of the more significant of these discussions.

A study performed for the US Department of Energy and published in 1993 identified what it called "problems" with fuller implementation of biomass energy.[82] The first is the erroneous perception that burning wood for fuel produces undue noxious emissions and environmental degradation. The second is the problem of complicated and sometimes conflicting environmental regulations and policies. Specifically mentioned in this regard was the apparent conflict between policies of reducing solid waste and stringent air quality regulations.

82. Larry Dobson, *Biomass Energy: State of the Technology, Present Obstacles & Future Potential*, prepared for the U.S. Department of Energy, Conservation and Renewable Energy, Office of Energy Related Inventions, Washington DC, June 1993.

The third problem identified is the nature and availability of fuel. This discussion includes mention of the variable quality of fuel, the fact that biomass fuels are locally generated and must be locally utilized to be cost-effective, and the fact that many areas do not have dependable fuel delivery infrastructures. A final problem noted was one of defining the market. The discussion around this point specifically focussed on the general lack of knowledge about the potential of industrial wood energy and the poor perception toward its implementation.

A recent paper entitled "Key Federal and State Policies and Regulations Affecting Waste Wood for Energy"[83] focussed on air quality and solid waste disposal regulations as they affect and are affected by wood-fired energy production facilities. One example discussed in some detail is the 1990 Clean Air Act Amendments, and the fact that this federal legislation requires states to meet federal air quality standards or adopt tougher ones of their own. While this establishes minimum air quality requirements, it also sets up the possibility for uneven requirements from state to state and sometimes within states.

A similar situation is discussed with regard to solid waste disposal and the federal Resource Conservation and Recovery Act (RCRA). The authors noted that, while the federal government and many of the states have indicated their desire to increase the use of renewable energy sources, the legislation and regulatory policies on air quality and solid waste disposal are not consistently favorable to these goals. The study concluded that operators and proponents of biomass facilities needed to take a proactive role in the development of state policies and regulations in order to educate regulators of their special needs.

A more encompassing set of barriers is discussed in a publication put out by the Northeast Regional Biomass Program in October of 1992.[84] This study identified major barriers to biomass power production as falling into four main categories: (1) financial risk for investors, (2) inadequate information in the hands of decision-makers, (3) lack of coordination among regulators and other decision-makers who have to work together, and (4) unknown social and environmental impacts. The financial risks discussed involve working with relatively new applications of technology and the supply and infrastructure for harvesting and transporting fuel.

83. Christine T. Donovan and Eric S. Palola, "Key Federal and State Policies and Regulations Affecting Waste Wood for Energy" *Proceedings of the Fifth Annual Biofuels Conference and Exhibition*, October 19-22, 1992, pages 253-282.

84. Philip Lusk, Susan Savitt and Steve Morgan, *Northeast Regional Biomass Program: Mission, Accomplishments, Prospects: 1992*, Coalition of Northeastern Governors Policy Research Center, Washington, DC, October, 1992.

The problem of inadequate information appears to focus on facility operators as the decision-makers in question. Fuel supply and infrastructure problems, as well as environmental and technological concerns, can be placed in this category. Solid-waste disposal, air quality questions, and land-use issues are among those that necessitate regulatory agency coordination. Finally, the authors note that truer accounting of costs (including externalities and life-cycle costs) must be included when attempting to determine social and environmental costs and benefits relative to other energy technologies.

A third study that appeared in 1992 was entitled *Renewable Energy: Barriers and Opportunities, Walls and Bridges*.[85] This study also identified four major categories of barriers. The first is that the lack of up-to-date and reliable information on the cost and performance of renewable resources often means that they are left out of any utility planning processes involving increasing capacity.[86]

A second barrier is that commonly used resource planning and avoided cost methods understate the value of renewable resources. This point stressed the need to include factors such as environmental costs, benefits of dispersed small scale renewable resources, and new modeling techniques in the planning process.

The third barrier identified noted the difference in treatment between utility investments for facilities and power purchase arrangements which tend to produce a bias against projects with higher capital costs in favor of projects with lower capital costs even when the latter will have substantially higher fuel costs. Other power purchase practices, such as insurance, security provisions, and contract terms may also bias the process against renewables.

Finally, the fourth barrier identified was the time, expense and credibility of the regulatory process. The study cautioned that states with time-consuming, expensive, and unpredictable regulatory processes are less likely to see dramatic increases in the application of renewable resources.

A slightly older study, but one that specifically addressed the type of cogeneration facilities being studied here, is the *Assessment of Commercial and Industrial*

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85. David Moskovitz, *Renewable Energy: Barriers and Opportunities, Walls and Bridges*, The World Resources Institute, Regulatory Assistance Project, Gardiner, ME, July 1992, (Revised in September 1993).

86. It should be noted that over 45 percent of the respondents to the DNR survey above indicated that "don't know what options are available" and "don't know who to trust" were barriers to their pursuing biomass cogeneration at their facilities. The follow-up survey conducted as part of this study confirmed this to be a significant barrier in Michigan.

Cogeneration Potential In the Pacific Northwest.[87] This study identified five major deterrents to installing a cogeneration system at a site: (1) financial risk, (2) complexity of installing and operating a system, (3) lack of familiarity with the concept and the benefits, (4) lack of capital, and (5) uncertainty with regard to whether the host facility will remain in operation.

These concepts, all similar to those identified in the studies above, are mentioned in terms of the decision-making process a facility operator might go through in determining whether or not to install a cogeneration system. The discussion focusses on the need for the facility owner to feel adequately compensated for the risks being taken.

Taken as a group, these studies tend to support the findings of the 1993 DNR study and the follow-up survey performed in Michigan during 1994. Lack of up-front funding for systems, environmental and other regulatory concerns, and a lack of knowledge of the options and the benefits of the technologies appear to be among the most-mentioned barriers to implementation of small-scale biomass cogeneration. The question that remains, then, is what can be done to work toward overcoming these barriers?

Overcoming The Barriers

Federal and state policies and regulations have been identified consistently as major barriers to fuller implementation of biomass cogeneration. Streamlining policies and regulations, and making their intent and enforcement consistent (both with the goals and within geographic regions) can go a long way toward removing policies and regulations themselves as barriers. In addition, policies and regulations can be devised which may actively mitigate many of the other barriers identified.

The purpose of the following section is to provide a brief discussion of how some jurisdictions are approaching this task. For each barrier, the current situation in Michigan is followed by mention of approaches being taken by other states and regions within the United States.

It should be noted that, due to time and budget constraints of this project, this is not a comprehensive review of policies either in Michigan or in other parts of the country. It is meant, rather, to initiate discussions of what is possible.

87. *Assessment of Commercial and Industrial Cogeneration Potential in the Pacific Northwest*, Bonneville Power Administration, Portland, OR, 1989.

Barrier 1: Overall Lack of Information

The lack of information available to facility owners who might otherwise consider cogeneration at their facilities is a fundamental problem. The types of information that need to be made more readily available include data on the technological potential, economic potential, the licensing and regulatory arena, the reliability of fuel supply in the state, and the resources available for further help.

While some of this information is available in Michigan to someone willing to undertake a diligent search, the process of conducting the follow-up PSC survey described above illustrated that it is not easy to get necessary information for biomass cogeneration. In addition, and perhaps more importantly, what information there is that is easily obtained is generally geared toward larger facilities. Very little information exists specifically for the small facility operator who is interested in increasing the operating efficiency by self-generating power.

The Oregon Department of Energy (ODOE) addresses this problem by providing technical assistance and a number of publications to interested parties. One such publication, *The Oregon Bioenergy Guidebook*,[88] includes discussions on how to plan a bioenergy project, what biomass resources exist in the state, and what technologies exist for taking advantage of those resources. There is also a detailed discussion of the agencies, permits, standards and regulations that apply to a facility, and lists for each type of technology that indicate the types of permits necessary and the agencies that issue those permits. Finally, there is a guide to the biomass energy facilities in the state to assist interested persons in finding out the experiences of facilities that have such systems.

Other states have produced comparable guides and Michigan is in the process of updating its similar publication now. North Carolina, for instance, has published a *Wood Energy Guide for North Carolina*.[89] This document includes discussions of the resources available, the major wood industry groups in the state, technical, economic and environmental issues, and the opportunities that exist in the state. The state of Maryland released a similarly comprehensive guide in 1990.[90] The state of Alabama has also

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88. International Resources Unlimited, *Oregon Bioenergy Guidebook*, prepared for the Oregon Department of Energy, Salem, OR, September 1993.

89. Laila Guessous, John G. Cleland and Wayne S. Leary, *Wood Energy Guide for North Carolina*, op. cit.

90. *A Guide to Maryland's Regulation of Forest Products Industries: Energy Conservation, Energy Production and Environmental Protection Through Production and Utilization of a Renewable Resource*, Maryland Energy Administration, June, 1990.

produced a number of publications on the topic, including surveys of industrial cogeneration operators and case-studies of successful facilities.[91]

The Northwest Power Planning Council (NWPPC), a federally mandated energy planning body covering the states of Idaho, Montana, Oregon, and Washington, is beginning the process of updating its plan. As a part of that process, the Washington State Energy Office has been asked to study biomass fuel supply in the region, including forest, mill and agricultural residue, energy plantation concepts, landfill gas recovery, and sewage treatment and animal manure products. Technologies and economic potential will also be evaluated. A "bioenergy briefing paper" is expected to emerge from this study in October of 1994.[92]

Barrier 2: Up-Front Costs of Systems

Even when all other barriers are addressed and it appears prudent for a facility operator to pursue installation of a cogeneration system, the problem of how to pay for it emerges as a significant barrier. The costs in question include not only the equipment itself, but the costs of a feasibility study, the technical and legal expenses of obtaining necessary permits and negotiating new arrangements with utilities, the design of the system, and the modifications to the existing facility in order to accommodate the new equipment.

Currently it appears that the state of Michigan has no policies or programs designed to assist facility operators with these expenses.

The state of Wisconsin has a program designed specifically to assist facilities with these problems. The Renewable Energy Assistance Program has been providing grants to facilities interested in biomass generation for approximately three years. Grants fall into two categories. Technical assistance grants fund feasibility studies to determine if sites are good candidates for a system. Grants designed to offset construction costs are also available.[93] This program is funded for a minimum of two more years.[94]

A number of other states have grant programs that specifically fund demonstration projects or innovative projects based on industry, technology, or geographic location.

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91. For information on the Alabama publications, contact the Energy Division, Alabama Department of Economic and Community Affairs.

92. For more information on this report, contact Jeff King, Northwest Power Planning Council.

93. Although the program is designed for all types of renewable energy systems, in practice most of the projects receiving grants have been wood-burning facilities.

94. For more information about programs and policies in the state of Wisconsin, contact Dan Moran, Wisconsin Energy Bureau.

Aside from outright grants, another method of easing some of the burden of the initial project costs is to make financing readily available. A carefully designed utility program could assist boiler owners and operators with both information and financial services at the time of boiler replacement.

Barrier 3: Obtaining Financing

Although 100 percent financing is seldom available, loans with favorable terms are one way of assisting facility owners with the costs of installing cogeneration systems. Policies can be put in place that provide direct loans, and other policies can be instituted that help create a climate that makes obtaining private financing easier.

Michigan does not currently have a program of providing direct loans to facilities for the purposes being described here. The state does, however, have one program in place that helps larger facilities obtain financing. Public Act 81 of 1987 requires contracts between independent power producers (IPP's) and utilities under PURPA to last at least 17.5 years, guaranteeing a purchase price and thus income generation for independent power producers. This guarantee makes financing such projects more attractive, and has contributed to Michigan being a leader in non-utility-owned hydro and renewable energy production, including biomass.[95] It should be noted, however, that this policy assists larger facilities that will sell power to utilities, but does not help owners of smaller systems designed to meet on-site needs only.

The state of Oregon has had innovative and aggressive promotion of biomass energy facilities for a number of years. The state has instituted a Small Scale Energy Loan Program through which qualifying facilities can finance nearly all costs of installing an energy system. In addition, in 1982, when federal energy tax credits were beginning to decline, the state instituted a business energy tax credit whereby a business can write off 35 percent of a project cost over five years. Although not specifically a loan, this program does reduce the costs of a system and thereby make it easier to obtain a loan.[96]

The state of New York takes a similar approach through its Energy Investment Loan Program. Commercial wood energy projects can qualify for loan assistance under this program.[97] A number of other states also have similar programs.[98]

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95. Michael C. Brower, et. al., *Powering The Midwest*, op. cit. For more information on this policy contact Robin Barfoot at the Michigan Public Service Commission.

96. For additional information on biomass programs in the state of Oregon, contact Alex Sifford, Oregon Department of Energy.

97. Environmental Risk Limited and C.T. Donovan Associates Inc., *Wood Products in the Waste Stream: Characterization and Combustion Emissions*, prepared for the New York State Energy Research and

Barrier 4: Environmental Concerns and Regulations

The primary environmental regulations of concern to most facility operators will have to do with solid waste disposal, land-use, and air emissions requirements. The goals of policy makers working to overcome this barrier should include identifying and quantifying the trade-offs with these issues. For instance, are we willing to accept some air pollution in exchange for a reduction in material that would otherwise end up in a landfill?).

Then, policy makers need to turn their attention towards three goals: (1) establishing an internally consistent set of regulations that reflect those policies, (2) specifying how these regulations apply to small facilities as well as larger ones, and (3) assuring that these regulations are enforced uniformly throughout the state. Streamlining the environmental permitting process and making sure that information about it is accessible to interested persons are also very important.

Michigan's Solid Waste Management Act (Public Act 641 of 1978) governs most of the solid waste management issues in the state. Two more recent amendments to the law serve as an example of complementary legislation that could increase fuel supplies while alleviating solid waste disposal problems. Public Act 264 of 1990 banned landfilling of yard waste from public properties in 1993, and will expand that restriction to all yard waste in 1995. Concurrently, Public Act 267 of 1990 placed a ban on backyard open burning of yard waste in municipalities with populations greater than 7,500. These laws are creating significant increases in the amount of organic material being composted in the state. Similar policies on timber harvest and wood processing wastes could also potentially increase the availability of fuel stocks dramatically.

Federal clean air requirements will only apply to large sources in the state of Michigan. Plants with approximately eight megawatts capacity and smaller will be subject only to state regulations.[99] The Michigan DNR is the agency with primary responsibility for enforcing those regulations.[100] Although a site-specific review would be required in each instance, it appears that the environmental permitting process would be quite simple under current law in Michigan if a facility is already operating a boiler and wishes to

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Development Authority, Albany, NY, November 1992.

98. Jan Hamrin and Nancy Rader, *Investing in the Future: A Regulator's Guide to Renewables*, op. cit.

99. This restriction will vary depending on fuel type, boiler capacity, location of the plant, and other factors.

100. For information on state regulations as they apply to biomass cogeneration systems, contact Lynn Fiedler, Combustion Process Unit, Michigan Department of Natural Resources.

install cogeneration equipment that will not markedly increase emissions of the current system. If capacity were to increase, or if fuel-switching were involved, then the permitting process would become more involved. Michigan DNR officials stressed that getting them involved early simplifies the process in the long-run.

The state of Wisconsin has a number of policies in effect designed to promote biomass energy production and cogeneration. The state's recycling law, which has been in place for more than five years, has established a hierarchy similar to that in Michigan: reduce, reuse, recycle, burn with energy recovery, and landfill. The Wisconsin recycling law, and the more recent enactment of an energy bill, mandates a set of priorities which ranks energy production from biomass over landfilling.[101] Although this is the state's official policy, however, regional officials charged with enforcing air quality standards have made carrying out the policy difficult in some instances.

To help clear some of the confusion, the state legislature approved a policy statement in May 1994 establishing a hierarchy for meeting new energy needs. This placed renewables and efficiency at the top of the list. Although not a mandate for state agencies, this statement does help to provide consistency between environmental regulations and will serve as a valuable tool to those who are working to expand biomass generation in the state.

Educating the public, policy makers, and regulators is also a key to successful environmental policy. Many of the states that lead in use of biomass fuels have issued regulatory statements clearly expounding the environmental benefits of wood as a fuel. For instance, California, Vermont, Connecticut, Washington and North Carolina have all explicitly recognized in policy statements that wood is a cleaner burning fuel than many fossil fuels and does not result in net contributions of greenhouse gasses.[102] Others have explicitly recognized the ties between these interrelated issues.

Another way to educate the public and to nudge utility planners along in the right direction is to specifically require that air pollution and other "externality" costs be considered in resource planning or ratemaking decisions. This has already happened in states such as California, Connecticut, New York, Vermont, Wisconsin, Massachusetts,

101. See Wisconsin Act 335 of 1989 for more detail on the recycling law, and Wisconsin Act 414 of 1993 for more detail on the state's energy development priorities. For more information about programs and policies in the state of Wisconsin, contact Dan Moran, Wisconsin Energy Bureau. For more information on Michigan's recycling hierarchy and wood energy development, see the *Solid Waste Management Act* (i.e., Public Act 641 of 1978) op. cit., and the *Michigan Wood Energy Development Plan, An Addendum to Michigan's Forest Resources, A Statewide Forest Resources Plan*, op. cit.

102. *Wood Products in the Waste Stream: Characterization and Combustion Emissions*, op. cit.

Nevada and others.[103] Such policies can have the effect of encouraging utilities to purchase power from cleaner more environmentally benign facilities, and make renewable energy technologies more attractive. With the playing field more levelized, a positive climate for cogeneration investments would be created, further encouraging the smaller facilities being studied here.

Barrier 5: Other Regulations and Utility Policies

Other significant sets of regulations that must be addressed by any facility operator are those that dictate the relationship between the facility and the local utility. If a facility is about to begin generating some or all of the electricity that it previously purchased from the utility, agreements must be reached that describe how much electricity will be supplied to the facility and under what conditions, what will happen if the facility is unable to produce its own power for short or long periods of time, and under what conditions the utility will purchase surplus electricity from the facility. These arrangements are dictated by state and federal regulations as well as by utility policies and practices.

Michigan currently has a law on the books requiring the two largest utilities in the state to acquire 120 MW each of waste and biomass electric capacity during the next ten years or so. However, the law does not specify ownership of this capacity, and recently most of the emphasis ha been on waste (especially landfill gas and mixed municipal solid waste facilities) rather than biomass.[104]

Public Act 81 of 1987, which requires a 17.5 year contract period for utility purchase of independently produced power, is another example of legislation establishing terms between cogenerators and utilities. The state also has a policy of requiring utilities to put acquisition of large generating facilities out for bid and acquire energy on a least-cost basis, which could put privately owned biomass facilities on the same footing as more traditional sources.[105] It should be noted again, however, that these policies are aimed

103. Ibid. See also Jonathan Becker, *Energy Audit: A State-by-State Profile of Energy Consumption and Conservation*, Second Edition, prepared by Public Citizen, Critical Mass Energy Project, Washington, DC, 1992.

104. For more information, contact Robin Barfoot at the Michigan Public Service Commission.

105. See Case No. U-9798 before the Michigan Public Service Commission, July 22, 1992, Order Adopting Competitive Bidding Framework. The utilities themselves, as well as all interested parties (i.e., qualifying facilities as defined by PURPA of 1978) are eligible to participate in the bid process to provide electric capacity in Michigan in the future. For more background on implementing PURPA in Michigan see Case No. U-6798 before the Michigan Public Service Commission, August 27, 1982, Final Order in the Proceedings to Implement Provisions Set Forth in Title II, Section 210, of the Public Utility Regulatory Policies Act (PURPA) of 1978 RE: Cogeneration and Small Power Production.

at larger facilities and do not specifically address the needs of smaller scale cogenerators that are the focus of this study.

The reality of energy demand in the state and utility policies also affect the attractiveness of cogeneration systems. Although Detroit Edison's most recent Integrated Resource Plan predicted no need for additional capacity until the year 2002,[106] as part of a settlement agreement with other interested parties it was determined they will file a Request for Proposals in May of 1995.[107] Consumers Power Company (CPCo) plans indicate a need for additional capacity sooner[108] and it is possible they will file a Request for Proposals with the Commission some time in 1995.[109]

The existing surplus capacity lessens the utility's desire to look for other sources (including self-generation) and reduces the potential income for cogeneration facilities who might otherwise generate and sell excess power to the utilities. In addition, Detroit Edison has very high, demand-ratcheted stand-by rates,[110] which further discourage smaller facilities from generating their own power.

There are several areas in which state policies could make biomass cogeneration more attractive. The first would be to reduce or eliminate prohibitively expensive stand-by rates. Another would be to encourage the sale of power to utilities. This can be done by legislating an energy purchase rate that would be attractive to the cogenerator, as was done in Iowa.[111] It can also be accomplished by legislating a rate of return on utility

106. Detroit Edison Company, *Integrated Resource Plan 1992-2006*, May 1992.

107. According to communications with Robin Barfoot at the Michigan Public Service Commission in June 1994, the details of the Request for Proposals will be subject to a complete hearing, review and ultimate approval by the PSC before it is finalized and sent out to solicit bids.

108. Consumers Power Company, *1992 Integrated Resource Planning Report*, 1992.

109. Based on information provided by Ms. Barfoot and Tom Stanton at the Michigan Public Service Commission.

110. As noted above, stand-by rates are the rates charged by the utility to assure that in the event the facility's power generation system cannot meet the facility's need, the utility will be able to supply that power. Demand-ratcheted rates are those tied to the potential amount of need a facility might have. In other words, if a facility is producing 50 kW to meet its own needs, it will pay a stand-by rate for the potential that it may need 50 kW replacement power from the utility. If a facility is generating and using 250 kW, it will pay a proportionately higher rate for the assurance that the utility will be able to meet that need if necessary.

111. Michael C. Brower, et. al., *Powering the Midwest*, op. cit.

investments or purchases of power generated from renewable resources that is higher than for other investments or power purchases, as was done in Kansas.[112]

These again are examples of statutes designed to assist the larger facilities that will sell power back to utilities. Other legislation is in place that may specifically help the smaller facilities. The state of Connecticut, for instance, offers tax credits for renewable energy projects, including exemption from sales, use and property taxes.[113] North Carolina also offers a 15 percent tax credit for conversion of existing oil- or gas-fired industrial boilers to wood fuel.[114] As mentioned above, the state of Oregon offers a 35 percent business energy tax credit. The state of Iowa also offers property tax credit for owners of renewable energy installations, and the state of Wisconsin exempts fuel wood from the state's sales tax.[115]

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112. See Jan Hamrin and Nancy Rader, *Investing in the Future: A Regulator's Guide to Renewables*, op. cit.

113. Michigan previously had a similar Renewable Energy Tax Incentive program in the mid 1980s through the early 1990s encouraging residential purchases and installations of solar, wind and other energy conversion devices.

114. See *Wood Products in the Waste Stream: Characterization and Combustion Emissions*, op. cit..

115. See Michael C. Brower, et. al., *Powering the Midwest*, op. cit.

CONCLUSIONS

Michigan's existing biomass wastes have a strong potential to help diversify the state's energy mix, ease the increasing burden on the state's landfills and provide a viable tool for improving economic well-being within the state.

But all this will not happen on its own—at least not quickly. Another recent study estimated that just under 35 million tons of biomass residues are currently available with an aggregate energy value of more than 8,000 megawatts.[116] In spite of this potential, many of these residues are still being deposited in the state's landfills or left to decompose in fields or forests. Policies and incentives to encourage greater utilization are not in place to help Michigan industries and residents reap the benefits of these renewable resources.

The intent of this study was to provide useful policy oriented insights on small scale biomass cogeneration within the state of Michigan. To do this, the study focused on accurately identifying available and potential biomass resources and assessing the technical and economic potential for expanding biomass cogeneration in the state. With time, money and informational constraints, however, it was necessary to limit the scope of the study.

Instead of analyzing the total biomass resource potentially available for electricity generation, we focused our analysis on a small percentage of the available biomass resource. Similarly, only the wood products and food processing industries were included in the analysis of potential facilities. With these constraints in mind, and recognizing the need to develop a more comprehensive understanding of these industries and their energy use patterns, the findings should not be viewed as a definitive assessment of the biomass potential, but rather as an indication of the vast opportunity which exists if the state's entire biomass resources were to be more fully tapped.

FINDINGS

In spite of a large biomass resource, and many facilities which utilize wood for fuel, much of the state's energy related policies have encouraged primarily large scale powerplants. Aside from the pulp and paper industry which has traditionally generated much of its own power, the state's smaller facilities, and their potential to cogenerate and produce electricity have been overlooked.

116. See Tom Stanton, "Biomass Energy: It's Not Just for Breakfast Anymore," op. cit., page 2.

Assessing just under 1 million dry tons (i.e., approximately 20 percent of the total we identified) of the currently unused biomass residues, we found a technical potential for biomass cogeneration of almost 146 megawatts. This represents the potential generating capacity from 99 facilities currently using biomass boilers to generate steam needs and 15 facilities not currently using biomass boilers, but having the capability to convert.

We identified 99 facilities—all those currently using biomass fueled boilers—with economic potential to install biomass cogeneration. This subset of those with technical potential could generate an estimated 122 MW at costs below the existing per kWh rate paid and reflected a simple payback of 7.5 years or less. Approximately two-thirds of this economic potential could be derived from the lower peninsula although the eastern portion of the upper peninsula leads the state with just over 28 MW of potential. Assuming lower biomass costs or other cost savings, the economic potential in the survey population could rise another 24 MW.

Additional factors which can influence the cost-effectiveness of these investments and warrant further study are: emerging or advanced technologies with greater efficiencies and/or lower capital costs; changes in utility rates; diminishing fossil fuel supplies and rising costs; environmental regulations; and tax incentive programs similar to those Michigan had in place for residential renewable energy credits during the late 1980s and early 1990s.

Cost-effectiveness however, is not the only determining factor for proceeding. The prospective decision makers are currently facing numerous perceived and real barriers and constraints to greater adoption of biomass cogeneration. Foremost among these are: the lack of up front costs, environmental regulation, and lack of information. All need to be addressed if Michigan is to encourage cogeneration.

If Michigan chooses to continue on its present policy course with little added support for these small scale cogenerators, we estimate that market penetration of biomass cogeneration will only reach 39 MW by the year 2010. However, a modest program addressing these barriers could increase that penetration rate by 33 percent in the year 2010 and achieve 52 MW.

LESSONS LEARNED AND POLICY CONSIDERATIONS

Although the 122 MW of economic potential identified earlier in this report represents a very small piece of Michigan's total energy picture, it does represent a viable and expanding market for biomass residues, a means to help ease the burden on the state's landfills, and an opportunity to pursue significantly larger statewide benefits. If all 122 MW were installed, the initial investments from these retrofits would exceed $73 million—representing a significant market to be developed by Michigan industries. As the state of Maine discovered recently "[S]mall power producers are providing generating capacity from renewable resources and have been one of largest sources of new employment."[117]

Michigan's existing policies have not been directed at these fuel efficient, small scale cogenerators. However, direction from policy makers, coupled with utility support (e.g, providing technical information, assistance with financing, rebates or other services) could make the difference. Consideration for the needs of small scale systems (whether they be biomass, solar, natural gas or others) will help ensure the infrastructure for the small scale power industry is in place and mature, before significant new supply is needed, environmental regulations limit existing options and avoided costs rise.

Consistent with this thinking, a recent study of barriers and opportunities for renewable energy in the United States concludes, "One thing is clear -- renewable energy can play a much larger role in the nation's electricity supply than it does. Aggressive and creative actions by regulators, utilities, and other policy makers can make an enormous difference."[118]

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117. *Energy Choices Revisited*, op. cit., page 21.

118. See David Moskovitz, *Renewable Energy: Barriers and Opportunities, Walls and Bridges*, op. cit., page 48.

APPENDIX

BIOMASS CONVERSION FACTORS

The following table lists the conversion factors used to calculate biomass residue volumes reported in the DNR/FMD survey database, and used in this study of biomass cogeneration potential. These values were adapted from the *Michigan Wood and Paper Residue Study* (cited earlier), and reflect estimates from a variety of sources.

TABLE 12. BIOMASS CONVERSION FACTORS

Pallets	**Units**	**Btu/lb.**
board feet/pallet	12	
pounds/board foot	3	
pounds/pallets	35	7,000
Wood Residue	**lbs./cu.ft.**	**Btu/lb.**
Dunnage	35	7,000
Sawdust	12	7,000
Chips/shavings	10	7,000
Edging/cutoff	12	7,000
Bark	16	4,500
Other	11	7,000
Paper Residue	**lbs./cu.yd.**	**Btu/lb.**
White office	750	7,200
Corrugated	800	6,750
Coated	775	5,800
Paper board	775	5,400
Mixed	775	5,400
Other	775	6,000

BIOMASS CONVERSION TECHNOLOGIES

Biomass sources such as plants, trees, manure, municipal solid waste, forest and mill residues, food processing wastes and other forms of organic matter can be used to produce energy. The energy obtained from this biomass can, depending on the system design, be used to produce electricity, process heat for industry, space heat, mechanical power or a combination of the above.

In a biomass fueled cogeneration facility two forms of usable energy are produced from one fuel source. To accomplish this a typical facility has a boiler to combust the fuel and produce steam, and a steam turbine and generator to produce electricity.

The following information provides a brief overview of some of the different technologies and types of equipment used for biomass conversion processes and in cogeneration.

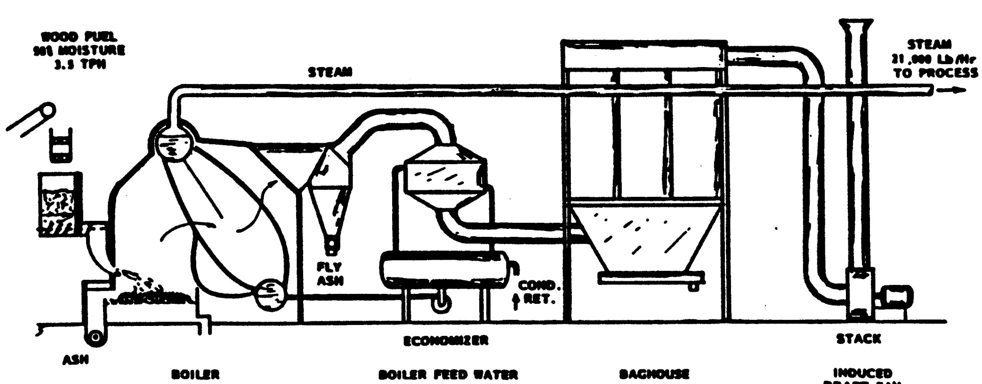
Biomass Converters

Two types of conversion technologies available to convert biomass into usable forms of energy are thermal and biological.

Thermal technologies use heat to produce chemical reactions in biofuels. These conversion technologies include: direct combustion, pyrolysis and gasification.

Direct Combustion is the burning of biomass materials with direct heat. It is the simplest and most common biofuel conversion process. The combustion heat is transferred by a boiler system to steam for process heat, power generation or both.

FIGURE 4. DIRECT COMBUSTION: WOOD FIRED BOILER

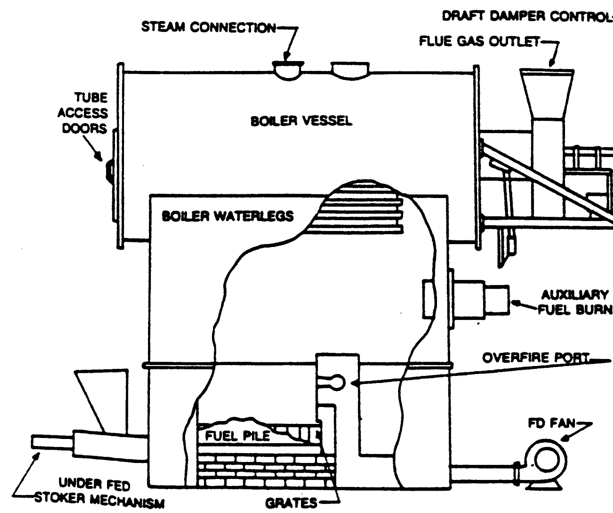


Source: T.R. Miles, Consulting Engineer, *Oregon Bioenergy Guidebook*, op.cit.

The three most common types of burners are pile, suspension and fluidized bed.

Pile burners — Fuel is burned in a thin pile or heaped and supported on a grate. Although less efficient than other boiler types, these burners have large areas of refractory material exposed to hot combustion gases. This design allows a large variety of feedstocks to be burned, including moist fuels with large quantities of dirt and debris.

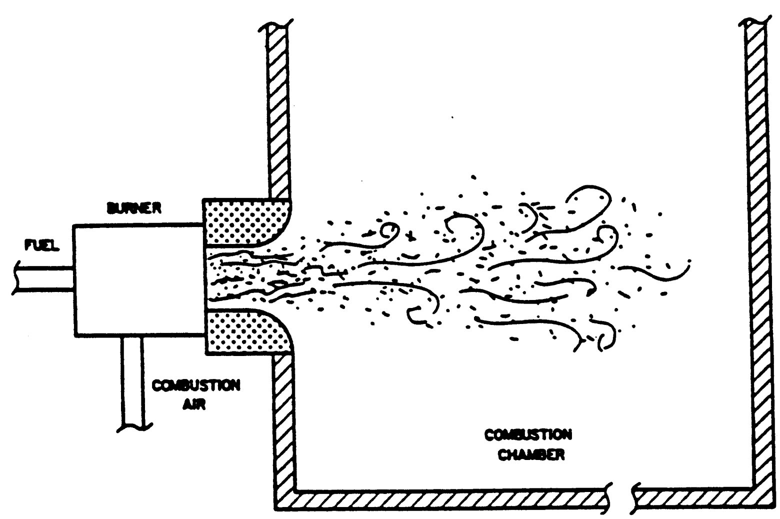
FIGURE 5. UNDERFEED STOKER PILE BURNER



Source: *Design Manual For Small Steam Turbines* , op. cit.

Suspension burners — Fuel particles are suspended and burned in a turbulent air stream. These burners can only be used with dry, small sized feedstocks such as wood chips and particles less than 1/4 inch in diameter. Thorough mixing of air and fuel produces high net efficiencies.

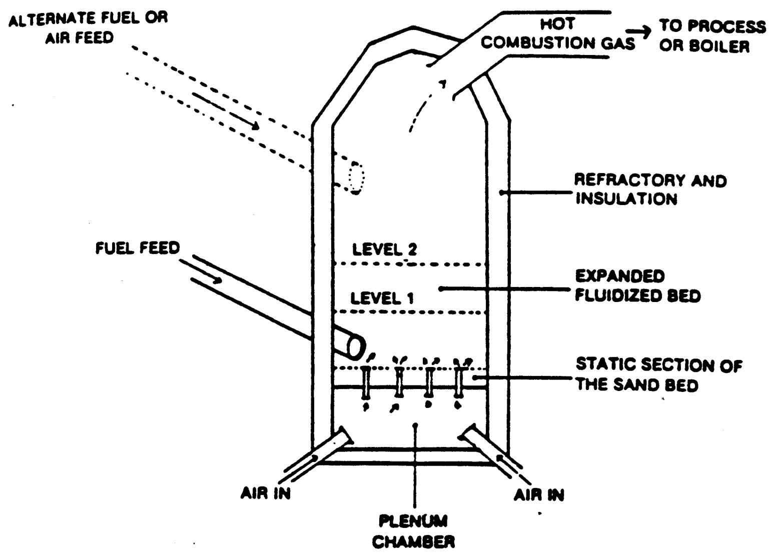
FIGURE 6. SUSPENSION BURNER



Source: *Design Manual For Small Steam Turbines*, ibid.

Fluidized bed — Fuel is burned on a high temperature bed of inert material agitated by air blown from below the bed. These burners are well suited to burning irregularly sized, wet or dirty fuels including: food processing wastes, wood wastes and agricultural wastes.

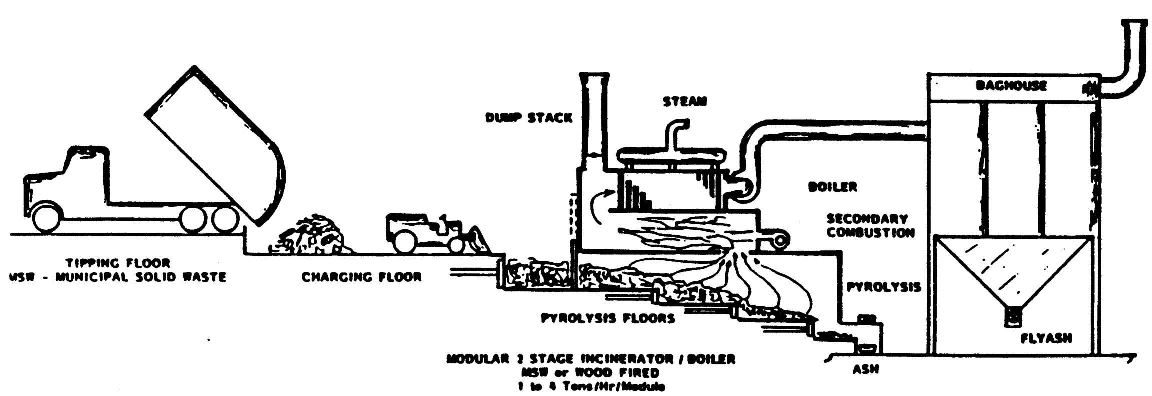
FIGURE 7. FLUIDIZED BED REACTOR VESSEL



Source: *Design Manual for Small Steam Turbines*, ibid.

Pyrolysis, another thermal technology, is the heating of biomass to extremely high temperatures with no oxygen to support combustion. Gas, fuel oil and charcoal are the usable byproducts with higher volumetric heat content. The fuels can be transported more easily and used in existing equipment.

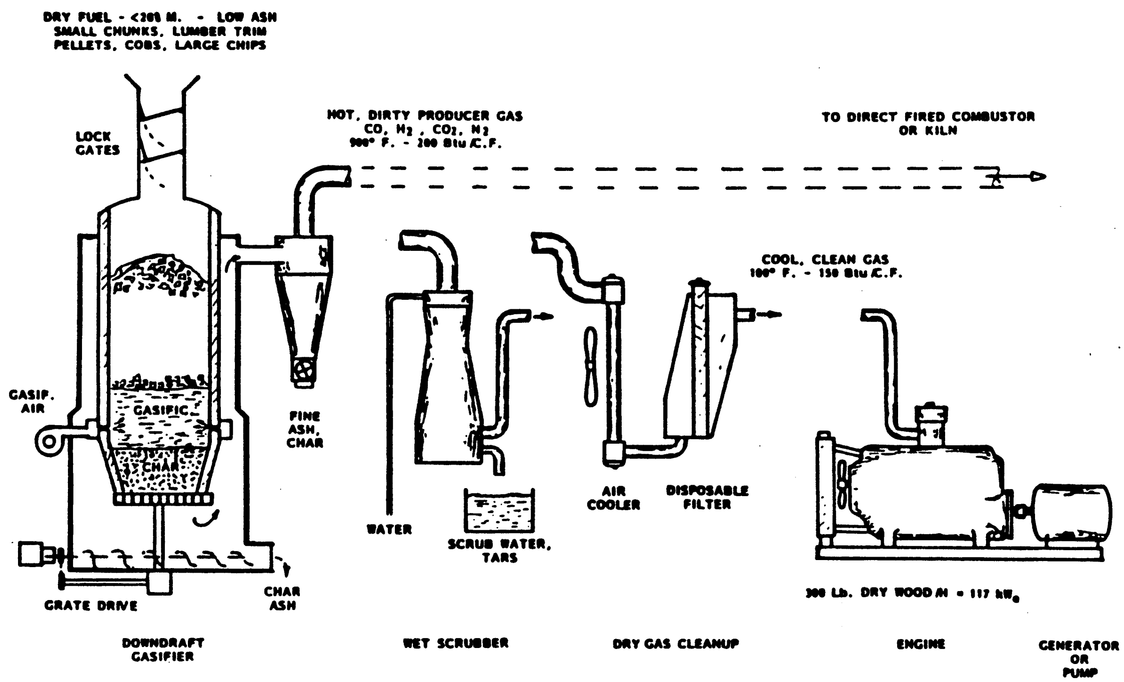
FIGURE 8. PYROLYSIS SYSTEM



Source: T.R. Miles, Consulting Engineer, *Oregon Bioenergy Guidebook*, op. cit.

Gasification, the third thermal technology, is the conversion of biomass to an intermediate gaseous product. Gases are drawn off and can be stored or piped into a burner for final combustion or used to fuel internal combustion engines.

FIGURE 9. BIOMASS GASIFICATION SYSTEM

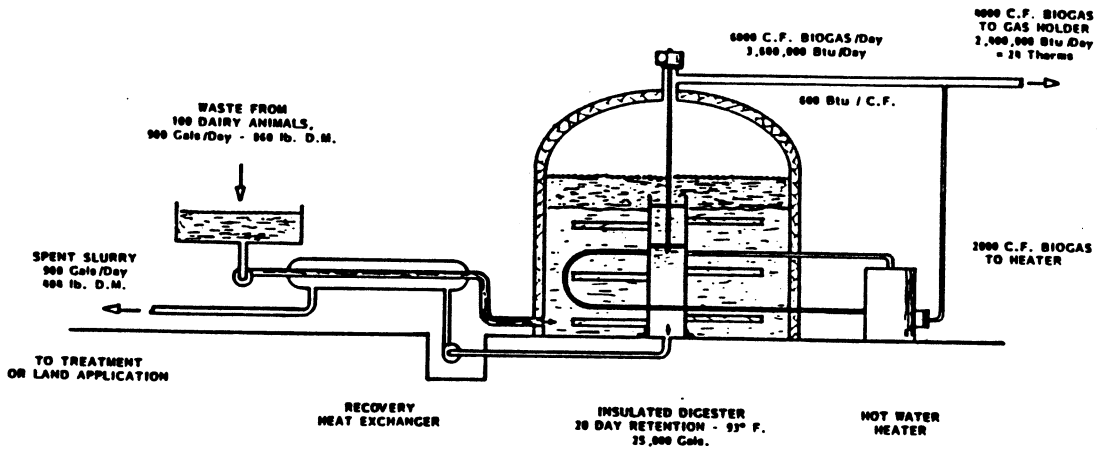


Source: T.R. Miles, Consulting Engineer, *Oregon Bioenergy Guidebook*, ibid.

Biological technologies include alcohol fermentation and anaerobic digestion.

Anaerobic digestion converts biomass (mixed with water) into biogas, liquid effluent, and sludge. The biogas (methane produced) can be used as a fuel source. These facilities are common with sewage treatment plants but they can also process animal manure and other cellulose materials. Landfill gas is generated by anaerobic digestion of organic wastes.

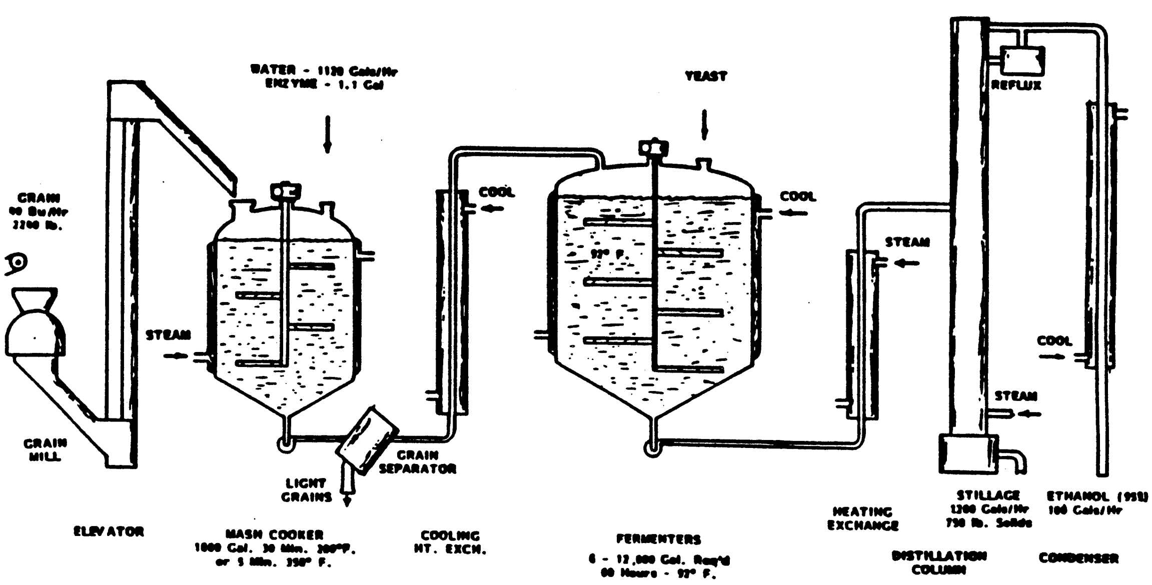
FIGURE 10. ANAEROBIC DIGESTION SYSTEM



Source: T.R. Miles, Consulting Engineer, *Oregon Bioenergy Guidebook*, ibid.

Alcohol fermentation converts biomass feedstocks (e.g., wheat, barley, potatoes, paper, sawdust, straw, etc.) to alcohol by fermentation with yeast. Ethanol is the alcohol product of fermentation usable as an alternative fuel in internal combustion engines.

FIGURE 11. ALCOHOL FERMENTATION SYSTEM

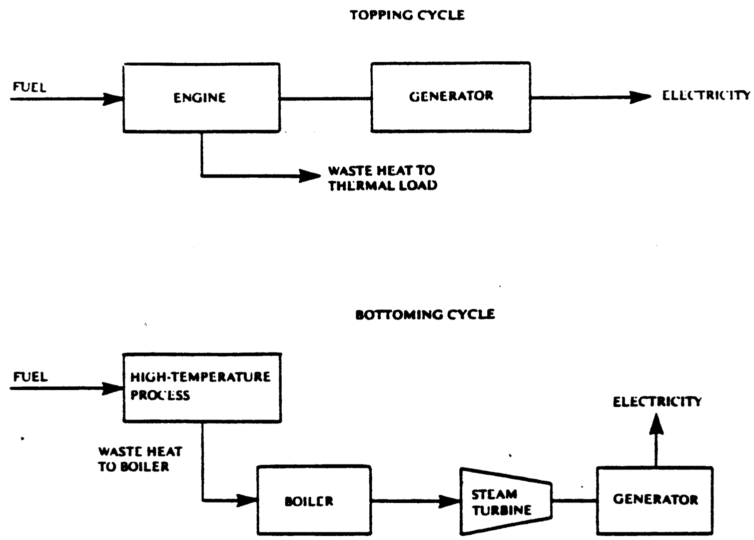


Source: T.R. Miles, Consulting Engineer, *Oregon Bioenergy Guidebook*, ibid.

Cogeneration Systems

Two basic cogeneration systems are available, the topping cycle and the bottoming cycle. In the topping cycle electricity is produced first and then the remaining heat is used for process heating. In the bottoming cycle, electricity is produced from the heat remaining in the steam after process heat requirements are met.

FIGURE 12. TOPPING AND BOTTOMING CYCLE COGENERATION SYSTEMS



Source: *Cogeneration From Biofuels: A Technical Guidebook*, op. cit.

Steam turbines, gas turbines, and internal combustion engines may be used as the prime movers depending on the amounts of process heat and electricity desired and the temperature of the process heating application.

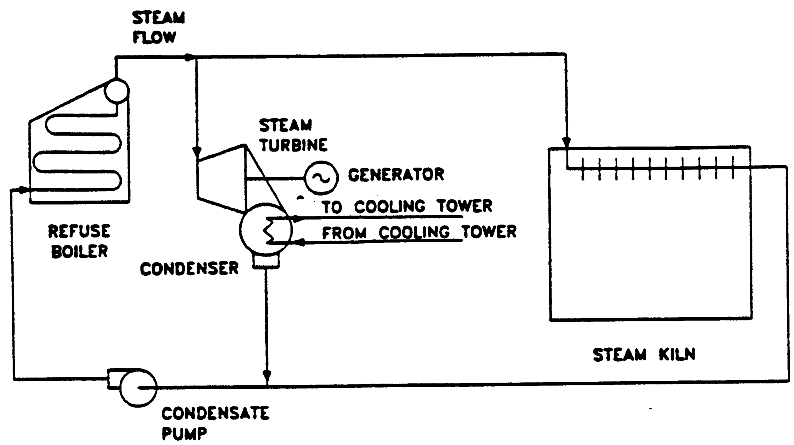
Although bottoming cycles require no additional fuel to generate power they require that waste heat be at a high enough temperature to produce the necessary steam to drive a turbine.

Prime Movers

Prime movers convert the thermal energy from steam or fuel gas into mechanical energy which can be used to spin a generator to produce electricity. Steam turbines, either condensing or noncondensing, are the most common mover for biomass cogeneration systems.

Condensing steam turbines are installed in parallel to the boiler and steam load, and produce power only when the boiler capacity exceeds the process steam requirements.

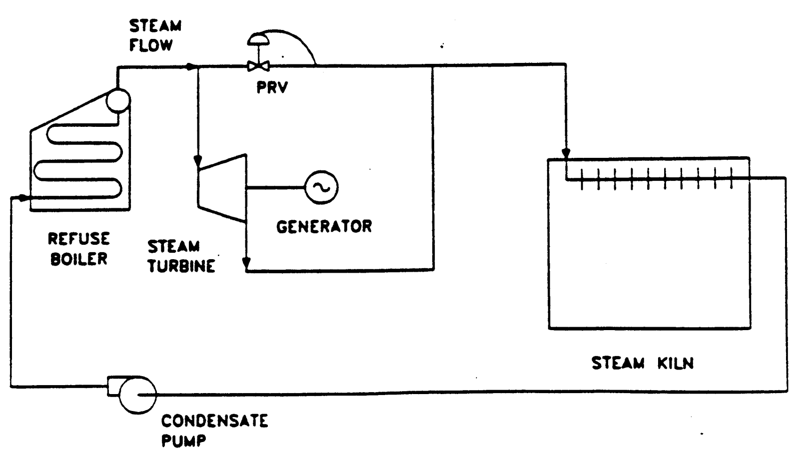
FIGURE 13. CONDENSING STEAM TURBINE SYSTEM



Source: George Wiltsee, Biomass-Fueled Cogeneration Systems, prepared for the Southeastern Regional Biomass Energy Program, Muscle Shoals, AL. 1993.

Noncondensing steam turbines are located in the steam line between the boiler and the steam load and only generate power when there is a demand for steam by the process equipment.

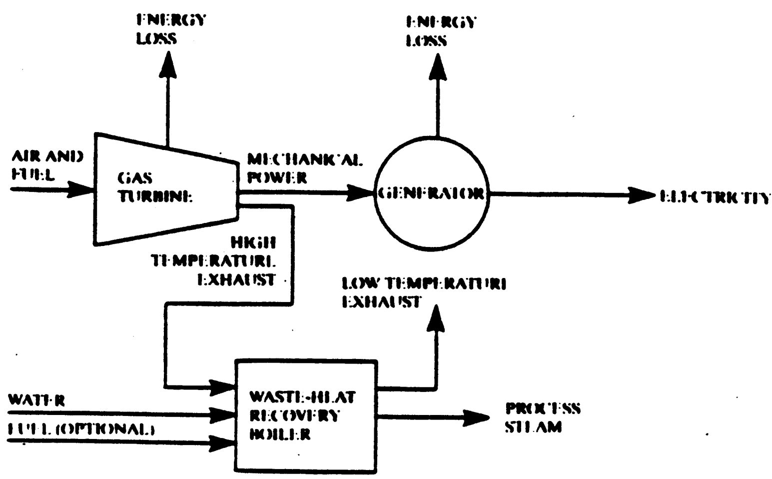
FIGURE 14. NONCONDENSING STEAM TURBINE SYSTEM



Source: Biomass-Fueled Cogeneration Systems, ibid.

Gas turbines are similar to stationary jet engines, using the gas produced by a biomass gasifier as fuel to produce shaft power for an electrical generator. High efficiency steam injected gas turbines (STIG) are considered the preferred state-of-the-art for natural gas based power production.

FIGURE 15. GAS TURBINE TOPPING SYSTEM



Source: *Cogeneration From Biofuels: A Technical Guidebook*, op. cit.

Electrical Generators

Two types of generators are available for cogeneration systems to produce electricity. **Synchronous generators** are self exciting and require a constant rotational speed to produce AC current at a constant 60 cycle frequency. Cogenerators require protective devices in order to interface with and sell power to utilities. **Induction generators** use electricity from the utility to energize their fields and produce no power when electricity from the grid is out.